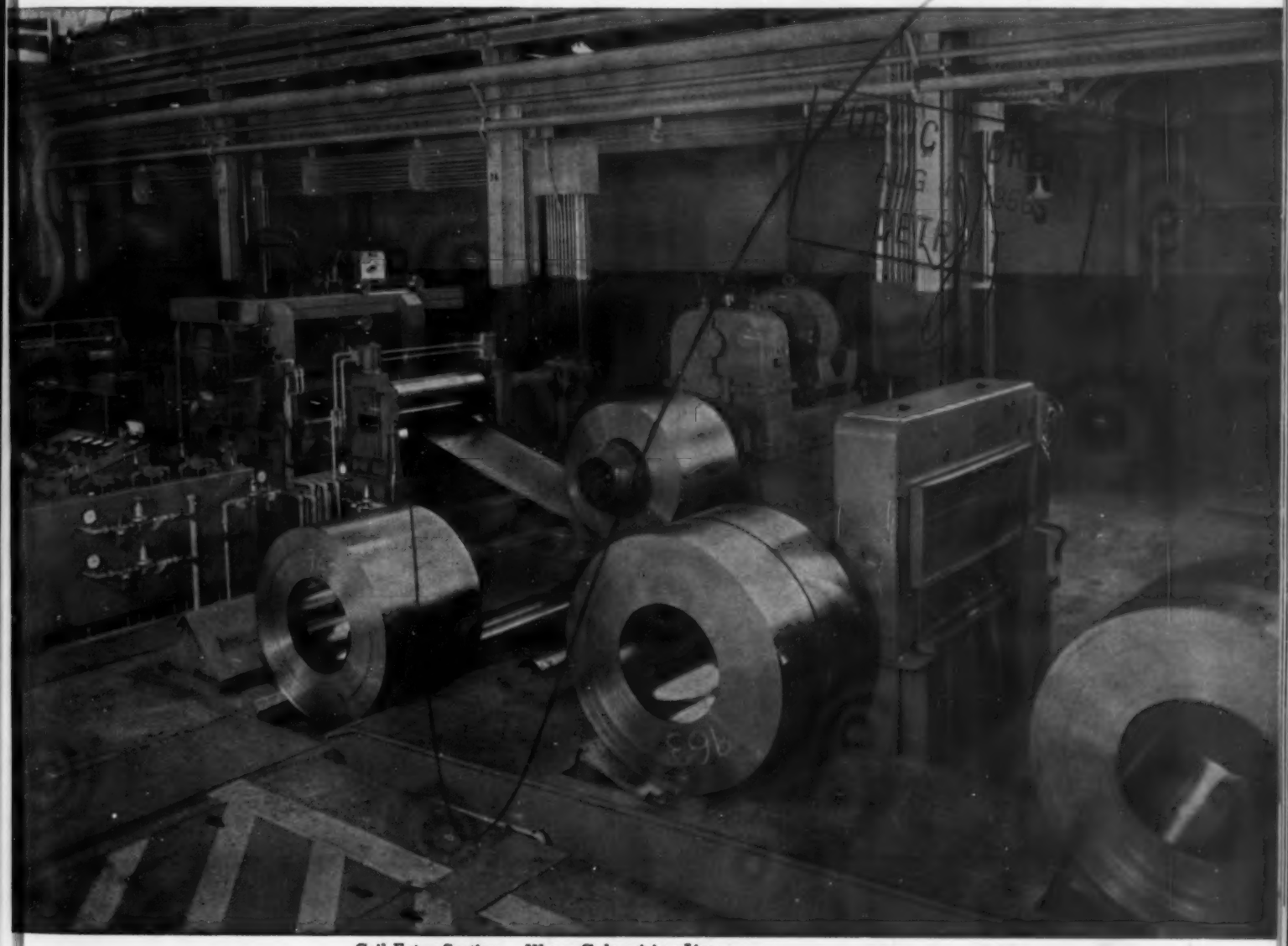
Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

JULY, 1956

TECHNOLOGY DEPT.

TABLE OF CONTENTS, PAGE 53



Coil Entry Section — Wean Galvanizing Line

The WEAN ENGINEERING COMPANY · INC.
Warren, Ohio

Typical of Wean Advanced Engineering is this continuous hot dip galvanizing line that produces a vastly improved zinc coat steel at greatly increased speeds. Heavier coatings, tighter bonding and greater uniformity are now possible at reduced costs. It's this kind of never ending search for better ways of making better steel products that has established Wean as the nation's foremost designer and builder of sheet, tin and strip mill equipment.

SPECIALISTS IN SHEET, STRIP AND TIN MILL EQUIPMENT

R v.33² Jy-D'56

AMERICAN BRASS CO. MILL MODERNIZATION

CUTLER-HAMMER Adjustable Voltage Control

HERE on single stand reversing cold mill #41.
HERE on single stand mill #43.
HERE on three stand flat wire mill.
and HERE on five stand tandem mill.

As a result of an expansion and improvement program recently completed, the Kenosha, Wisconsin Division of The American Brass Company becomes one of the most modern of all copper and brass mills. It handles 3000 lb. cakes of copper and copper alloys, for reduction to sheets, strips, rods and drawn products. *On performance* this subsidiary of *Anaconda* selected Cutler-Hammer adjustable voltage control for its major applications. CUTLER-HAMMER, Inc., 1269 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

CUTLER-HAMMER
MOTOR CONTROL
C-H

LOOK TO CUTLER-HAMMER MILL EXPERIENCE...AS BROAD AS IT IS LONG

Tech

IRON AND STEEL ENGINEER; published monthly by Association of Iron and Steel Engineers, 1010 Empire Bldg., Pittsburgh, Pa. Second class mail privileges

24

a-Built

CONTINUOUS

GALVANIZING

LINES

25th

UNDER WAY

WILL THE

26th

BE YOURS?

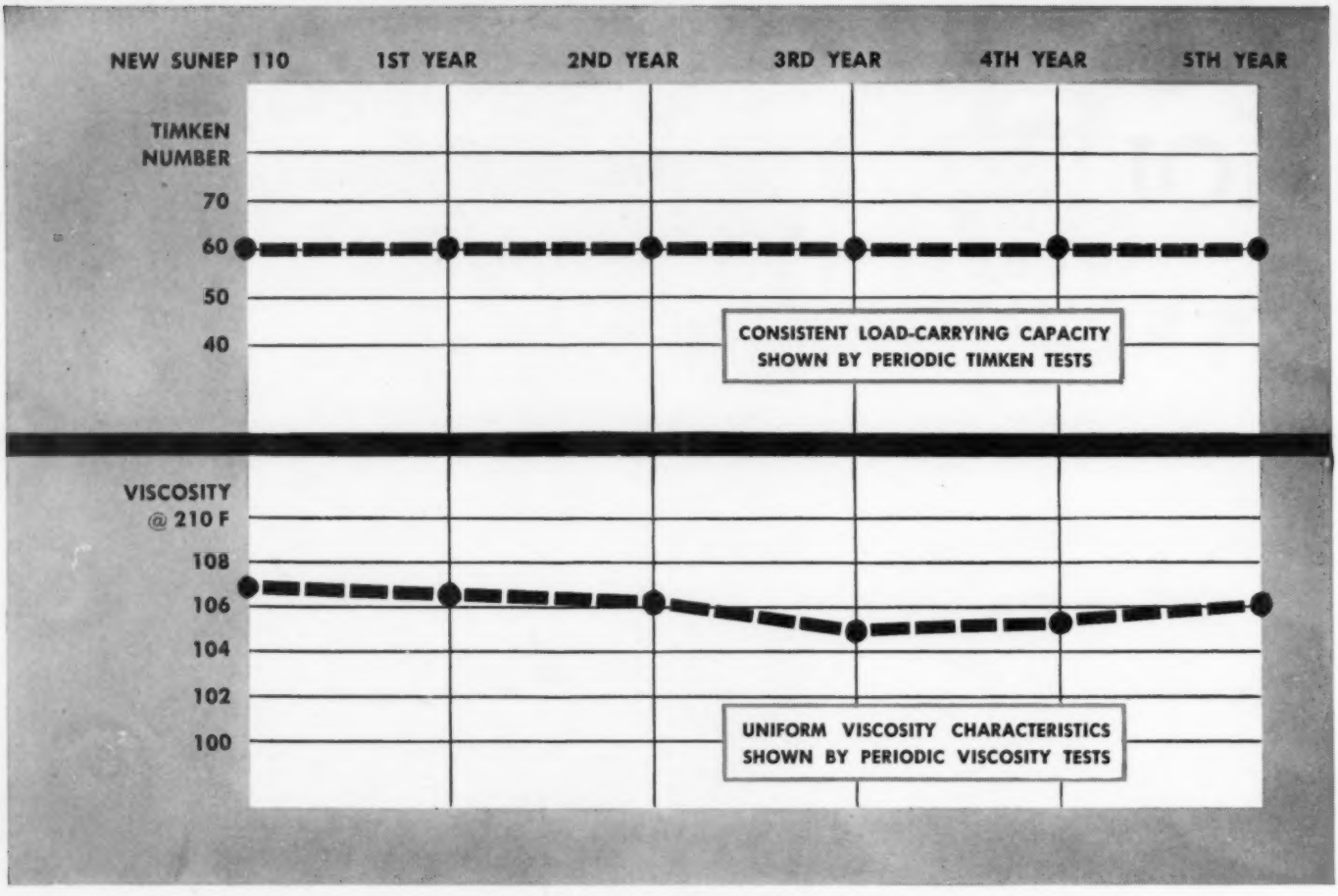
• The 26th line can be any process or type of Continuous Galvanizing in use today. Aetna-Standard has built more lines than all other manufacturers combined. If you are considering a continuous galvanizing line, Aetna has the facts, figures, production rates and other data on which you can base a sound decision. Why not make the 26th your line?

AETNA • STANDARD

THE AETNA-STANDARD ENGINEERING COMPANY

GENERAL OFFICES: PITTSBURGH, PA. PLANTS: ELLWOOD CITY, PA., WARREN, OHIO

CONTINUOUS GALVANIZING LINES • CONTINUOUS ELECTROLYTIC TINNING LINES • SIDE TRIMMING AND SHEAR LINES AND OTHER FINISHING EQUIPMENT • CONTINUOUS BUTT WELD PIPE MILLS • SEAMLESS TUBE MILLS • DRAWBENCHES AND OTHER COLD DRAW EQUIPMENT • ROLLS AND CASTINGS • EXTRUDERS, MILLS, PRESSES FOR RUBBER AND PLASTIC



Taken from the records of a major steel producer, the above graphs show the life record of a Sunep gear lubricant used in a 3-stand, 4-high cold-rolling mill. *With no make-up,* Sunep is as good as new after running more than 30,000 hours.

Steel company tests show:

SUNEP EXTREME-PRESSURE LUBRICANT REDUCES OIL AND MAINTENANCE COSTS

Sunep® lubricants help cut over-all oil costs because they have a long service life. They are made from high-quality base oils... unusual in the manufacture of extreme-pressure lubricants ...and because of this, are outstanding in their resistance to oxidation. They will not thicken or thin out in operation and will separate easily from water. Most important, they will last years longer than ordinary gear lubricants.

Sunep lubricants help keep maintenance down because they don't lose their e.p. qualities. They are specially blended to prevent "fall-out" of the extreme-pressure ingredients in service... a frequent and hidden cause of gear failure.

Sunep lubricants protect bearings and gears against rust and corrosion... an added help in reducing maintenance costs.

For complete information about Sunep lubricants see your Sun representative, or write for free Technical Bulletin 32. Address SUN OIL COMPANY, Philadelphia 3, Pa., Dept. IS-7

SUNOCO®

INDUSTRIAL PRODUCTS DEPARTMENT

SUN OIL COMPANY Philadelphia 3, Pa.

© SUN OIL CO.

IN CANADA: SUN OIL COMPANY LIMITED, TORONTO AND MONTREAL

THE CLARK CONTROLLER COMPANY

INTEROFFICE CORRESPONDENCE

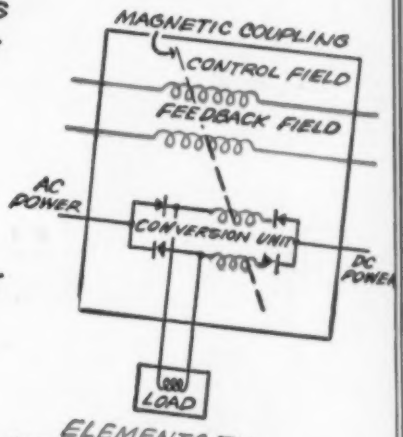
FROM: APPLIED ENGINEERING DEPT. TO: ADVERTISING DEPT.

SUBJECT: MAGNETIC AMPLIFIERS m/a

HERE ARE THE SIMPLE FACTS ABOUT OUR MAGNETIC AMPLIFIERS:

USED PRIMARILY AS INDUSTRIAL DRIVE REGULATORS ON CONTROL SYSTEMS, THEY CONSIST BASICALLY OF THREE MAGNETICALLY-COUPLED ELEMENTS:

1. A CONTROL FIELD -
2. A FEEDBACK FIELD -
3. A CONVERSION UNIT -

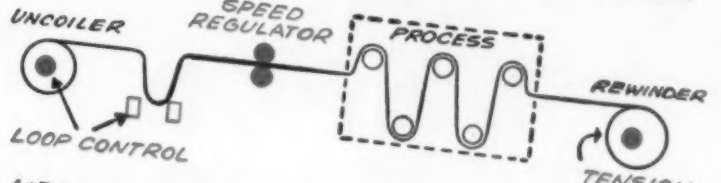


ELEMENTARY MAGNETIC AMPLIFIER

IF CONTROL FIELD AMPERE TURNS EXCEED FEEDBACK FIELD AMPERE TURNS IN A POSITIVE DIRECTION, OUTPUT IS TURNED ON. IF THE REVERSE OCCURS, OUTPUT IS TURNED OFF.

HERE'S HOW THIS IS APPLIED: IN A GENERATOR VOLTAGE REGULATOR, FOR EXAMPLE, THE CONTROL FIELD IS CONNECTED TO A REFERENCE SOURCE OF VOLTAGE, THE FEEDBACK FIELD TO THE ARMATURE TERMINALS, AND THE SHUNT FIELD TO THE LOAD TERMINALS. INCREASING AMPERE TURNS IN THE CONTROL FIELD TURNS ON THE REGULATOR, RAISING GENERATOR VOLTAGE UNTIL FEEDBACK BALANCES CONTROL FIELD, AT WHICH POINT THE SYSTEM STABILIZES.

AMONG THE MANY REGULATING SYSTEMS USING THIS PRINCIPLE ARE: CONSTANT TENSION COIL WINDING, SPEED REGULATION, POSITION REGULATION (LOOP CONTROL, EDGE CONTROL, SYNCHRONIZING CONVEYORS, ETC.).



MECHANICAL SCHEME FOR CONTINUOUS WEB OR STRIP PROCESSING CONTROL

THE MAGNETIC AMPLIFIER HAS ALMOST LIMITLESS APPLICATION AS A "SERVO" DEVICE TO MAINTAIN A PRE-DETERMINED RELATIONSHIP BETWEEN TWO FACTORS AS IN HEAT CONTROL, WEIGHT OR VOLUME CONTROL, PRESSURE CONTROL, TRANSDUCERS, METERING, CONTINUOUS PLATING CONTROL, ETC.

AS YOU CAN SEE FROM THE ABOVE, CLARK MAGNETIC AMPLIFIERS ARE IDEAL FOR USE IN AUTOMATION SYSTEMS. THEY ARE STATIC DEVICES WITHOUT TUBES, THUS REQUIRING NO WARM-UP TIME AND PRACTICALLY NO MAINTENANCE. THEY ARE FACTORY ADJUSTED, SIMPLIFYING INSTALLATION.

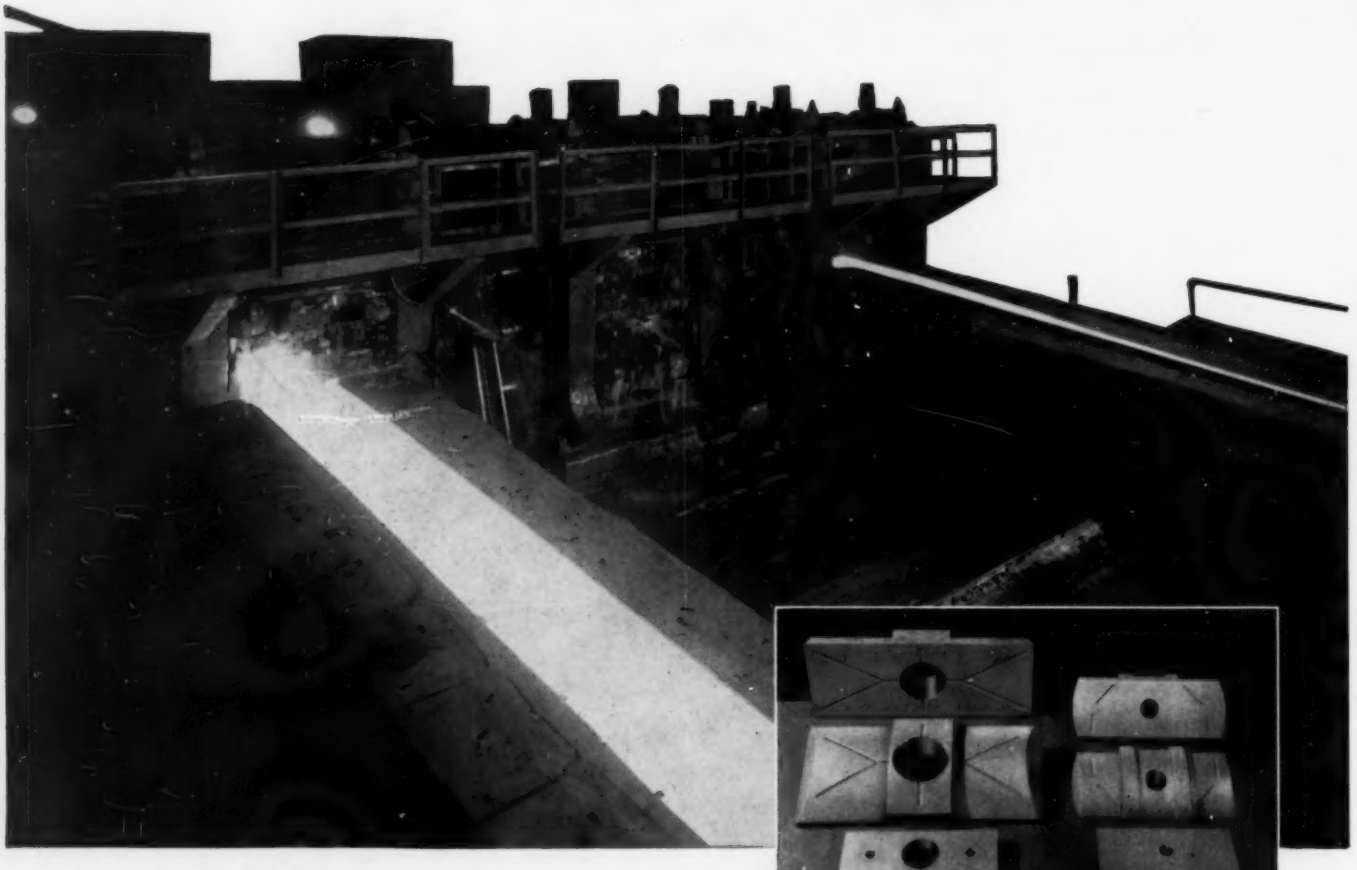
Clark's wide experience in applying magnetic amplifiers to industrial drives is at your service.

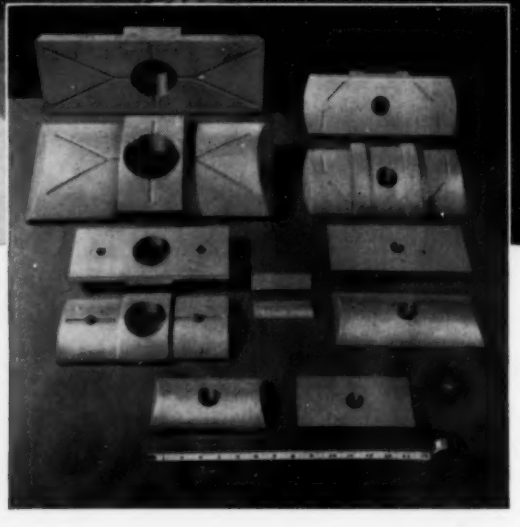
The CLARK CONTROLLER Company

Engineered Electrical Control

1146 East 152nd Street ▪ ▪ Cleveland 10, Ohio

Production Steps Up Costs Step Down





. . . when you use AMPCO* SLIPPERS

THERE'S plenty of "plus value" in slippers cast of Ampco Metal. They're tough — have unusual resistance to wear. They withstand the tremendous impacts and shock loads of steel-mill operation without squashing out. They have high fatigue strength.

These properties mean lower costs for you — less downtime — longer runs without replacement.

You get these slippers in the form you need to meet your specific operation. They're available "cast-to-size" or as rough castings. "Cast-to-size Slippers" come either with tolerances of minus 0, plus 1/32; or plus 0, minus 1/32. Oil grooves are cast in, if you want them.

And that's not all. Ampco Metal's stamina, toughness, and corrosion resistance mean that it's ideally suited for cutting costs in other steel-mill applications, too — screw-down nuts, wear plates, flash-welder dies, pickling equipment. Get the whole money-saving story from your nearby Ampco field engineer or write us direct

G-20

*Reg. U. S. Pat. Off.

AMPCO METAL, INC.

DEPT. IS-7, 1740 S. 38TH STREET
MILWAUKEE 46, WISCONSIN

West of the Rockies it's Ampco's Burbank Plant, Burbank, California

Something NEW in large gate valves!

Operating records show that it takes 6 men two hours to open an old-fashioned 72" hand-wheel-actuated gate valve.

The new Semet-Solvay hydraulically-operated 72" valve* can be opened manually by one man in 17 minutes . . . and by a small motor-driven pump in just 2½ minutes!

Semet's new valves have these advantages, too:

- the hydraulic pump, manual or motor-driven, can be located either at the valve, or remotely.
- one small motor-driven pump can be used to serve a group of valves.
- a dial type position indicator is provided and may be located either at the valve or at some remote point.
- each valve is equipped with a mechanical locking device to lock the valve in open position, or, optionally, in any position.
- all operating mechanism is mounted in a completely dust-tight, enclosed yoke.
- a pair of powerful jack screws is provided to release valve gates frozen from disuse.
- two large clean-outs are provided below the gates.
- construction can be of cast iron, cast steel, fabricated steel, or special alloy.
- they are available in gate valve and goggle valve types.

Specialists in designing and fabricating custom-made processing equipment, Semet will provide accurate estimates from your specifications or blueprints. Write to us for additional information.

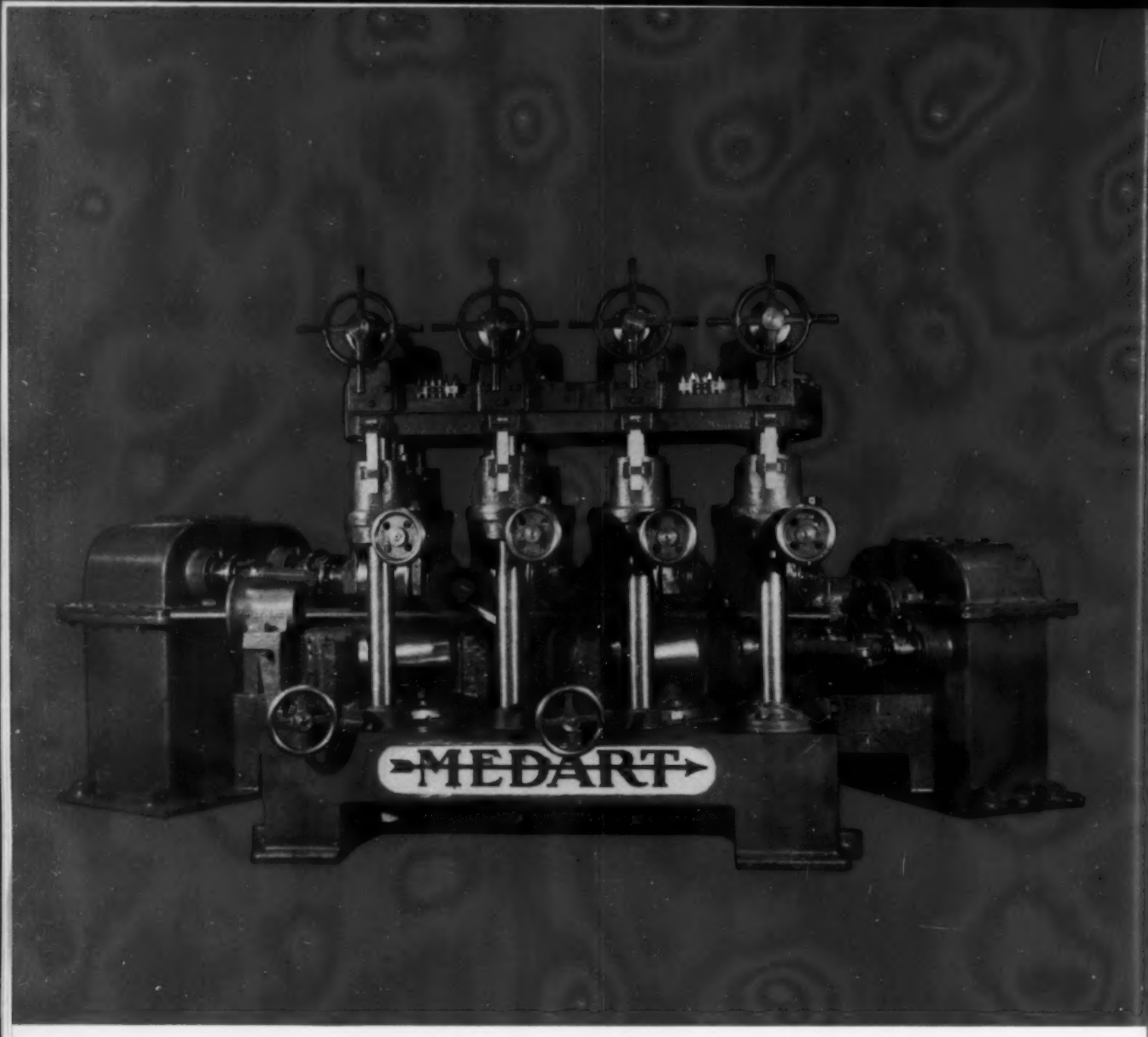
Semet-Solvay Engineering Division

Allied Chemical

ALLIED CHEMICAL & DYE CORPORATION, *40 Rector Street, New York 6, N. Y.*

DESIGNERS • ENGINEERS • FABRICATORS • ERECTORS

*Patents applied for



BLAW-KNOX MEDART makes what it takes

for high speed, Multiroll Tube straightening

Developed to meet the requirements of pipe and tube mills, the Blaw-Knox Medart Multicycle Rotary Straightener delivers high speed precision straightening of pipe and tubular products. It differs from other six roll machines in that the sixth roll is also a straightening or bending roll. In conjunction with the middle bending roll, it imposes a duplex straightening cycle on the workpiece.

Unbalanced torque on the workpiece is eliminated since all four feed rolls are driven from a single motor. This insures positive, synchronized feed and torque balance. What's more, this application of balanced torque permits thin wall tubular straightening not possible with other types of machines. Delivery speed is limited only by the condition and properties of the workpiece which may limit the torque and pressure applied.

The Blaw-Knox Medart Multicycle Rotary Straightener is available in all sizes for handling materials in diameters ranging from ¼" to 18". Larger sizes will be designed upon request.

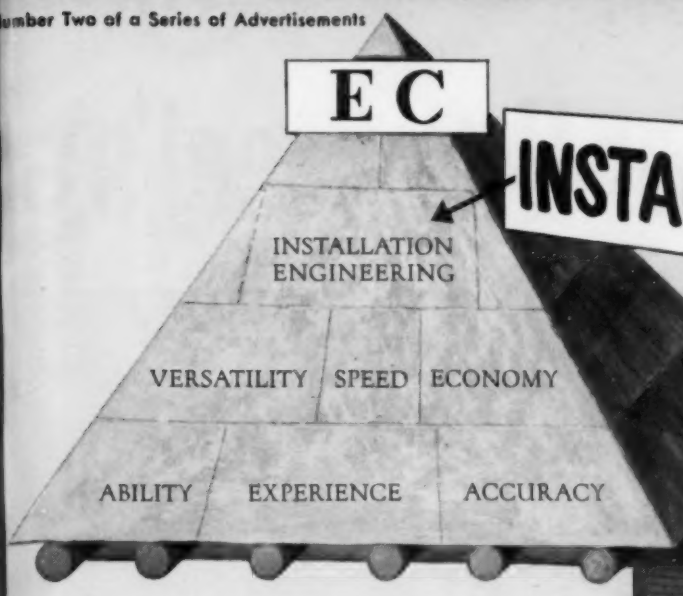
Contact us at any time for detailed information, technical assistance or service.

50th Anniversary
BLAW-KNOX
1906-1956

BLAW-KNOX COMPANY
Foundry and Mill Machinery Division
Blaw-Knox Building • 300 Sixth Avenue
Pittsburgh 22, Pennsylvania

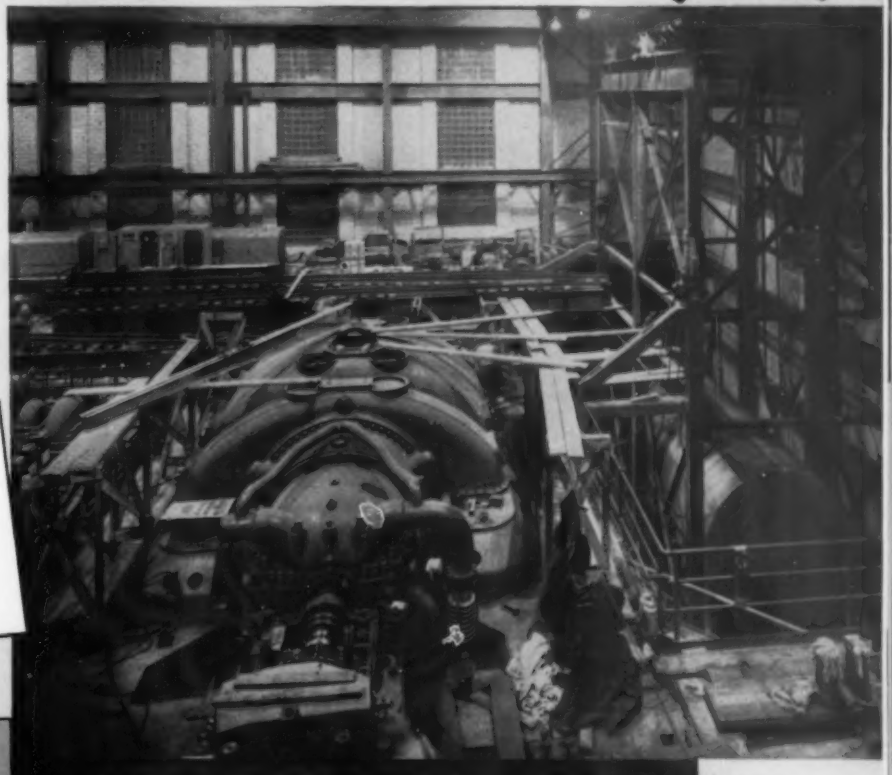
CONTINENTAL Foundry & Machine

Number Two of a Series of Advertisements



INSTALLATION ENGINEERING

Tower holding Stator ⬆ ⬇ Tower lifting Stator



The installation engineering required to properly install a 197-ton stator typifies the application of knowledge and ingenuity with which the Eichleay Corporation approaches each machinery erection program.

Pre-planning for this project at the Delaware Station of the Philadelphia Electric Company indicated space limitations, low headroom, no overhead facilities of sufficient capacity and a necessity for lifting and moving the stator in one piece. The solution to all of these restrictions was the design, fabrication and use of a lifting tower. By using the tower the Eichleay Corporation performed one of its typical difficult installations in an expeditious, safe, and economical manner.

The Eichleay Corporation services are available for any industrial program and can be adapted to your special problem.

Eichleay Services

Industrial Installations
Construction of Heavy Foundations
Building and Machinery Moving
Shoring - Rigging

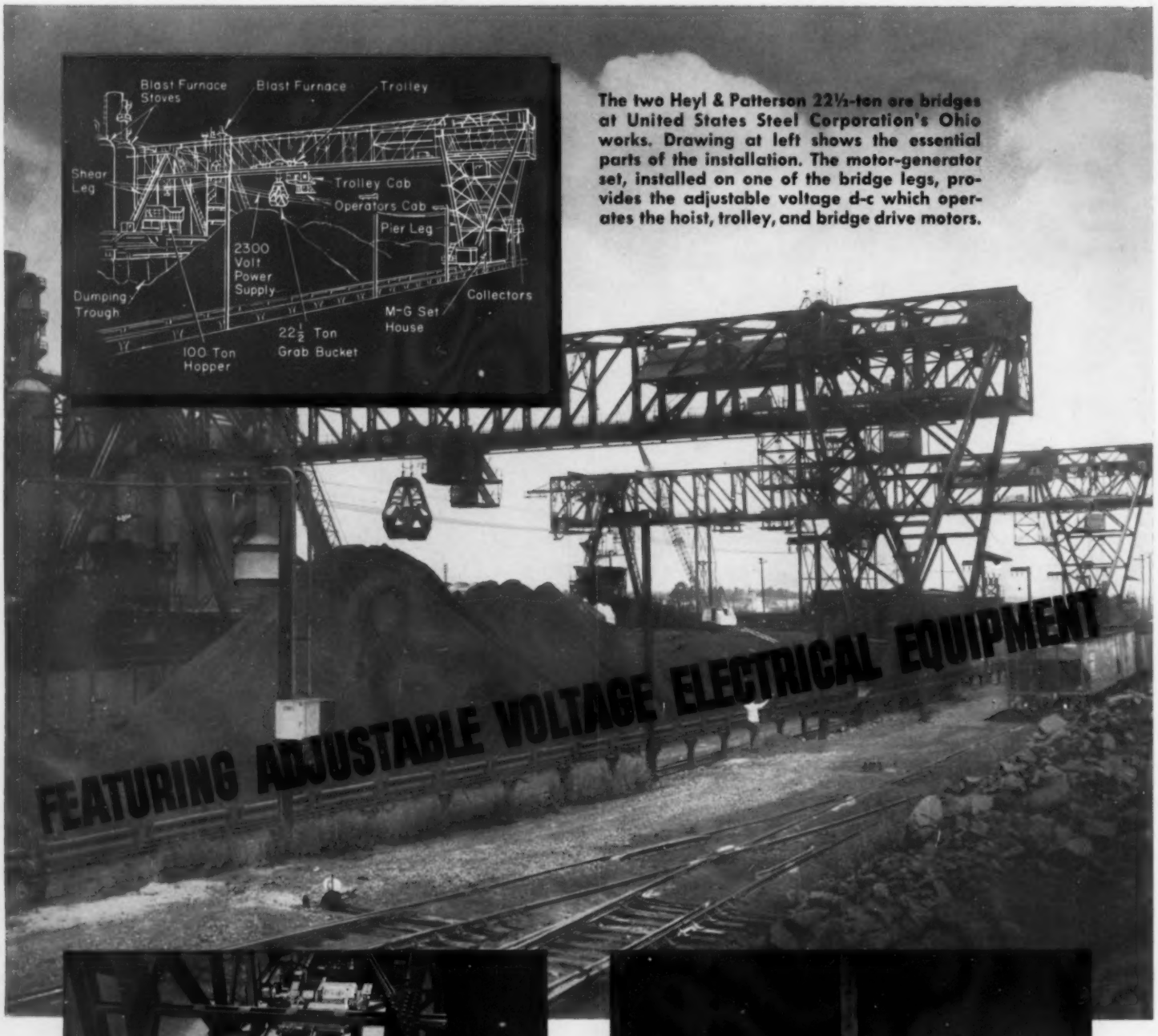
Eichleay

ESTABLISHED 1875

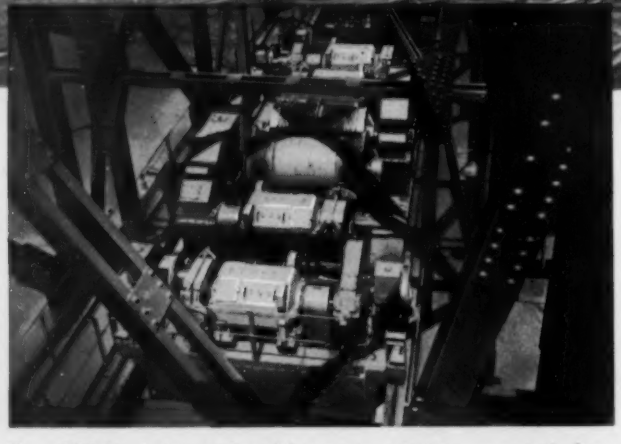
CORPORATION

33 S. 19th St., Pittsburgh 3, Pa.
1180 Richard Ave., Santa Clara, Calif.

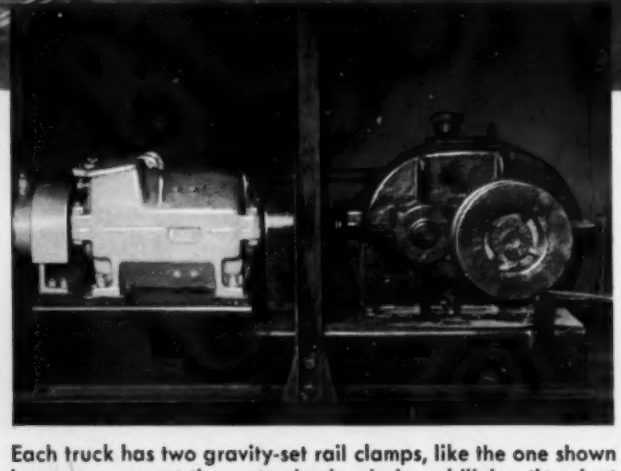
New ore bridges for U.S. Steel's



The two Heyl & Patterson 22½-ton ore bridges at United States Steel Corporation's Ohio works. Drawing at left shows the essential parts of the installation. The motor-generator set, installed on one of the bridge legs, provides the adjustable voltage d-c which operates the hoist, trolley, and bridge drive motors.



Two 250-hp hoist engine drive motors hoist, open and close the bucket. Outboard of these motors are two identical Elliott motors which drive the trolley along its rails.



Each truck has two gravity-set rail clamps, like the one shown here, to augment the motor brakes in immobilizing the giant 1300-ton structure on its track. A 6½-hp Elliott mill type motor releases clamp.

Ohio Works...

Elliott motor-generator set which converts incoming 2300-volt, 25-cycle power supply to adjustable voltage d-c. Two 250-kw generators in foreground supply bucket hoist and bridge travel motors. Larger 400-kw generator, in rear, supplies power for motors which drive the trolley.

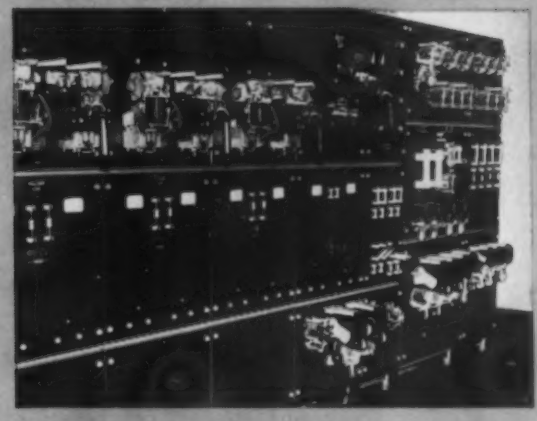
When increased blast furnace capacity required the installation of two new ore bridges at the United States Steel Corporation's Ohio Works, Youngstown, Ohio, designers incorporated all the most modern innovations and features. By using adjustable voltage electrical control, bridge motions are controlled more precisely and smoothly. Speed control is improved and hoisting speed is increased. In addition, greater bridge capacity is obtained without increase in the size or number of motors by operating the motors at near double-rated voltage and double speed. As the original power supply is a-c, no increase in d-c capacity of the plant is necessary. Other important advantages are less maintenance and less over-all power consumption.

BY ELLIOTT

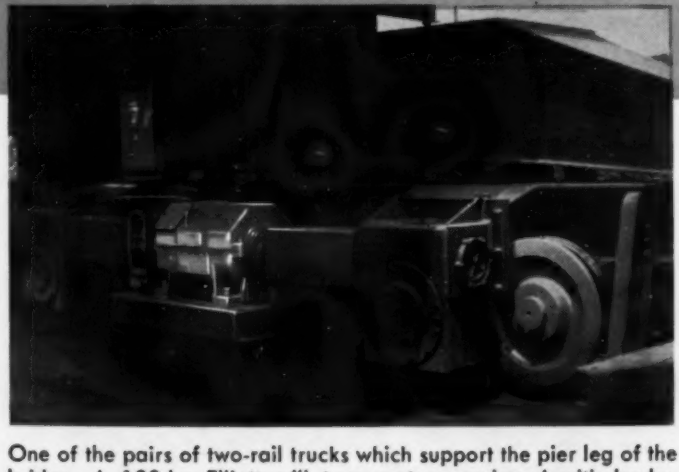
All major electrical equipment, including controls, was furnished by Elliott Company. Both Elliott engineers and Elliott equipment are thoroughly at home in steel mill operations. Take advantage of this experience. Consult your local Elliott field engineer or write Elliott Company, Crocker-Wheeler Division, Jeannette, Pa. for full information.

ELLIOTT Company

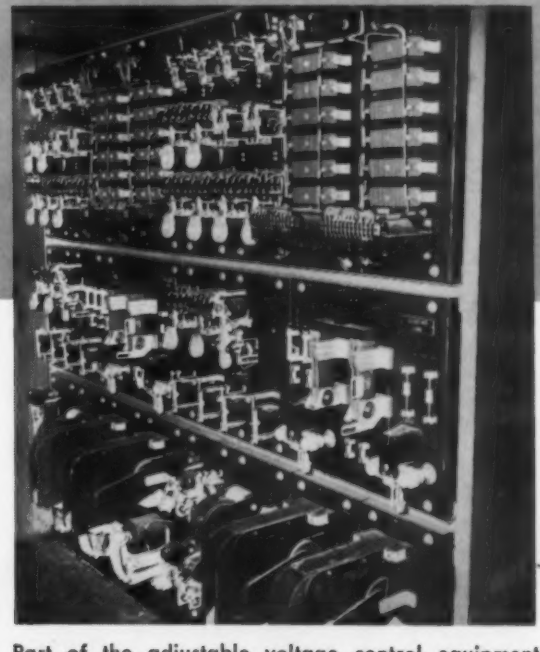
STEAM TURBINES • MOTORS • GENERATORS • DEAERATING HEATERS • EJECTORS • CONDENSERS • CENTRIFUGAL COMPRESSORS • TURBOCHARGERS • TUBE CLEANERS • STRAINERS



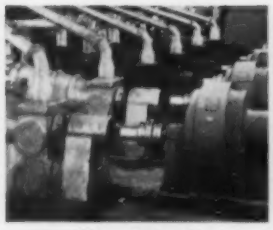
Control for the generators, located in the enclosed, pressurized motor-generator house.



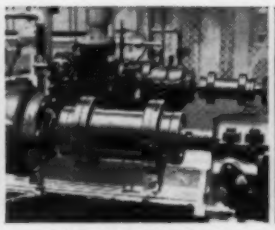
One of the pairs of two-rail trucks which support the pier leg of the bridge. A 100-hp Elliott mill type motor, equipped with brake, drives each truck.



Part of the adjustable voltage control equipment furnished by Elliott for each bridge. This is a portion of the motor control installed in the trolley cab.

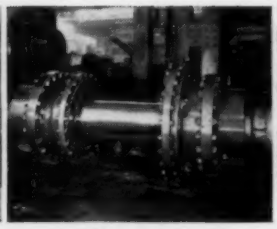


Paper Industry

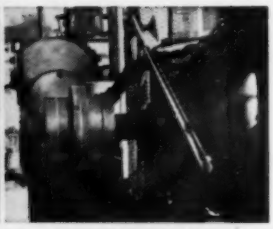


Oil and Gas Industry

Marine Industry

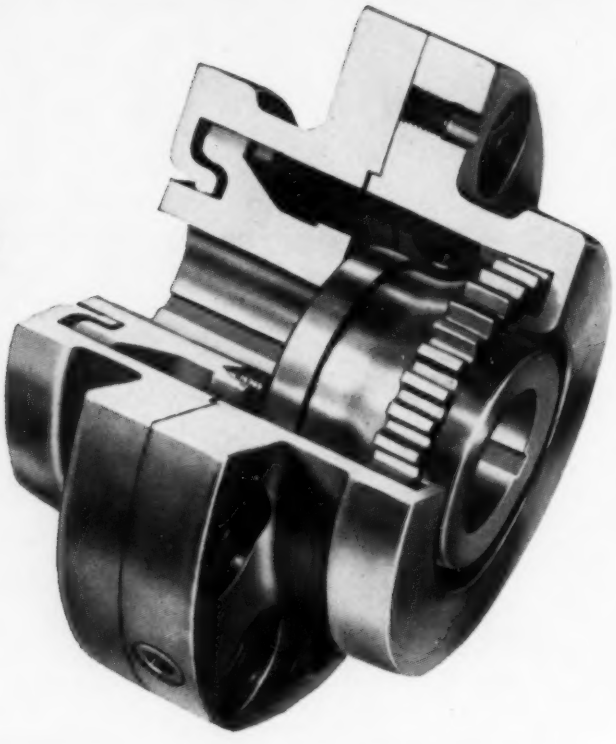


Steel Industry

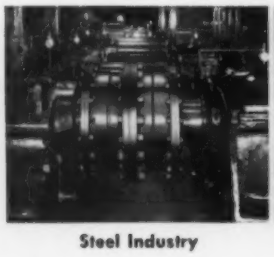


Oil and Gas Industry

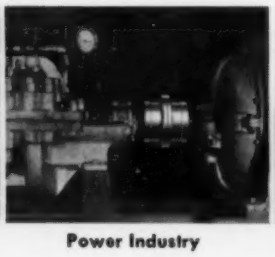
Why have Fast's Couplings always been the leader in the rugged steel industry?



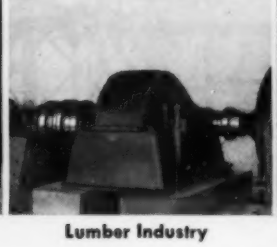
Why are they used so widely to couple machinery in Power Generation, Pulp and Paper, Oil and Gas, Marine Propulsion and Auxiliaries, Steel and industry in general?



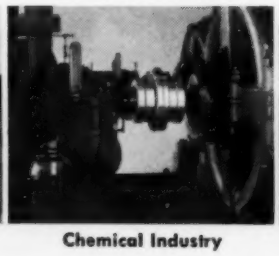
Steel Industry



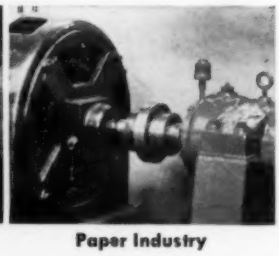
Power Industry



Lumber Industry



Chemical Industry



Paper Industry

Fast's Couplings are standard equipment with more machinery manufacturers than any shaft coupling on the American market. Many Fast's Couplings in use over 30 years still show no signs of wear when disassembled! That's the answer: they're reliable, they're *mechanically* flexible, they don't wear. They have no parts subject to repeated bending, tension or compression. There is no metal-to-metal contact, because of *positive lubrication.* Regardless of your field—no matter whether your connected machine is driven by steam turbine or electric motor, low-speed diesel or high-speed gas turbine . . . Koppers has the perfect, low-cost solution to your shaft coupling problem.

For free catalog write to: KOPPERS COMPANY, INC., *Fast's Coupling Dept.,* 3007 Scott St., Baltimore 3, Md.

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE 3, MD. This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Aeromaster Fans, Industrial Gas Cleaning Apparatus, Gas Apparatus.

Engineered Products Sold with *Service*

KOPPERS

THE ORIGINAL

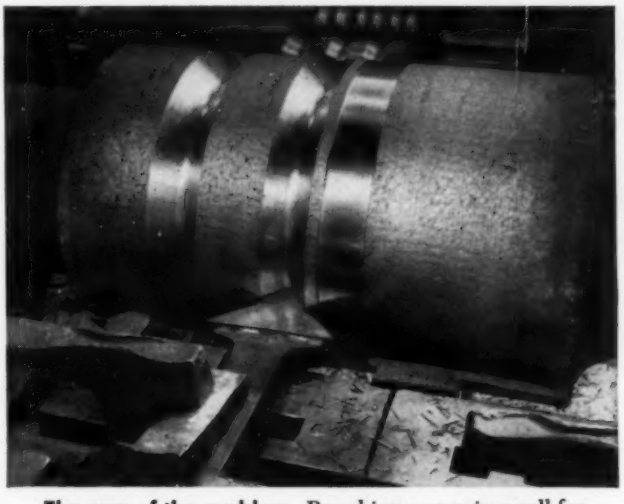
FAST'S Couplings

TIPS FROM A ROLL MAKER'S NOTEBOOK

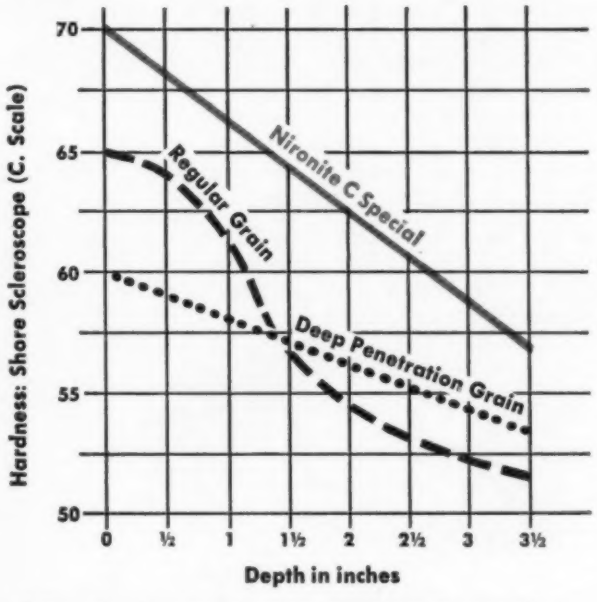
MACKINTOSH-HEMPHILL DIVISION, E. W. BLISS COMPANY, Pittsburgh 3, Pennsylvania

Cast mill rolls • Johnston cinder pots • rotary tube straighteners • end-thrust bearings • heavy-duty lathes • steel and special alloy castings

How to pick rolls for bar and billet mills



The crux of the problem—Roughing a pass in a roll for a bar mill.



Generalized curves show how hardness decreases below the surface of three types of roll.

Like all rolls, those for the intermediate and finishing stands of bar and billet mills must possess the best possible balance of strength-vs.-hardness. However, they cannot be chosen on this basis alone.

The problem is complicated by the shape and depth of the passes. Many rolls must be cast plain because of the size of the passes or because of the roll user's need for plain rolls which may be turned for any section. Hence, large amounts of metal must be removed during turning.

As a result the metallurgist strives for two prime objectives in rolls for these applications. They are (1) the greatest possible depth of hardness and (2) fine grain structure to provide smoothness of work surface at the bottom of the passes.

A practical solution—The Nironite C Special roll is the answer that Mack-Hemp has developed to meet this problem. In this indefinite chill nickel-chromium alloy iron roll, depth of penetration is achieved by careful control of the carbon content. This results in deep penetration as well as less and finer graphite in the solidified iron. Hardness decreases very gradually as distance from the surface increases (see graph at left). Thus, this manipulation of carbon provides excellent wear resistance even at the bottom of deep passes. And the low graphite content which is assured by this special composition provides excellent surface condition at depths well below the original surface.

Nironite C Special rolls are only one example of the way Mack-Hemp can combine metallurgical research with nearly five generations' experience in the "art" of roll making to improve the performance of modern rolling mills. For help with your special rolling problem, write us today.

MACKINTOSH-HEMPHILL

You get more tonnage from the rolls with the Striped Red Wabblers

DIVISION OF **E. W. BLISS COMPANY**

SAMUEL T. WELLMAN *was a horrified onlooker the day everything went wrong with the first open hearth furnace he had helped to build. Troubles reached their climax when the steel spilled out over molds, cars and tracks, welding everything into one mass as it chilled.*

This was in 1868. A year later, Wellman built a 5-ton open hearth furnace for the Bay State Iron Works, at South Boston. He used a much deeper bath and an arrangement of small ports, side by side with thin walls between, which gave a good mixture of gas and air. This furnace worked, and for years after produced ingots of the highest quality. It was America's first commercially successful open hearth furnace. Today, steel's greatest expansion is in open hearth capacity, increasing 36% between 1946-1955, to 110,234,160 net tons.

Great Names in Steel Making #II

Steel men respect success wherever met. But their special recognition is given to men and products that have helped the progress of steel.

An interesting example of this is the name "Gear Shield." In America there are mills in which the same gears have been lubricated with Gear Shield for 35 and 40 years. In consequence, the name has come to be so synonomous with satisfactory lubrication that other makers frequently refer to their lubricants as "gear shields" even though Gear Shield is the exclusive trade mark and product of The Ironsides Company.

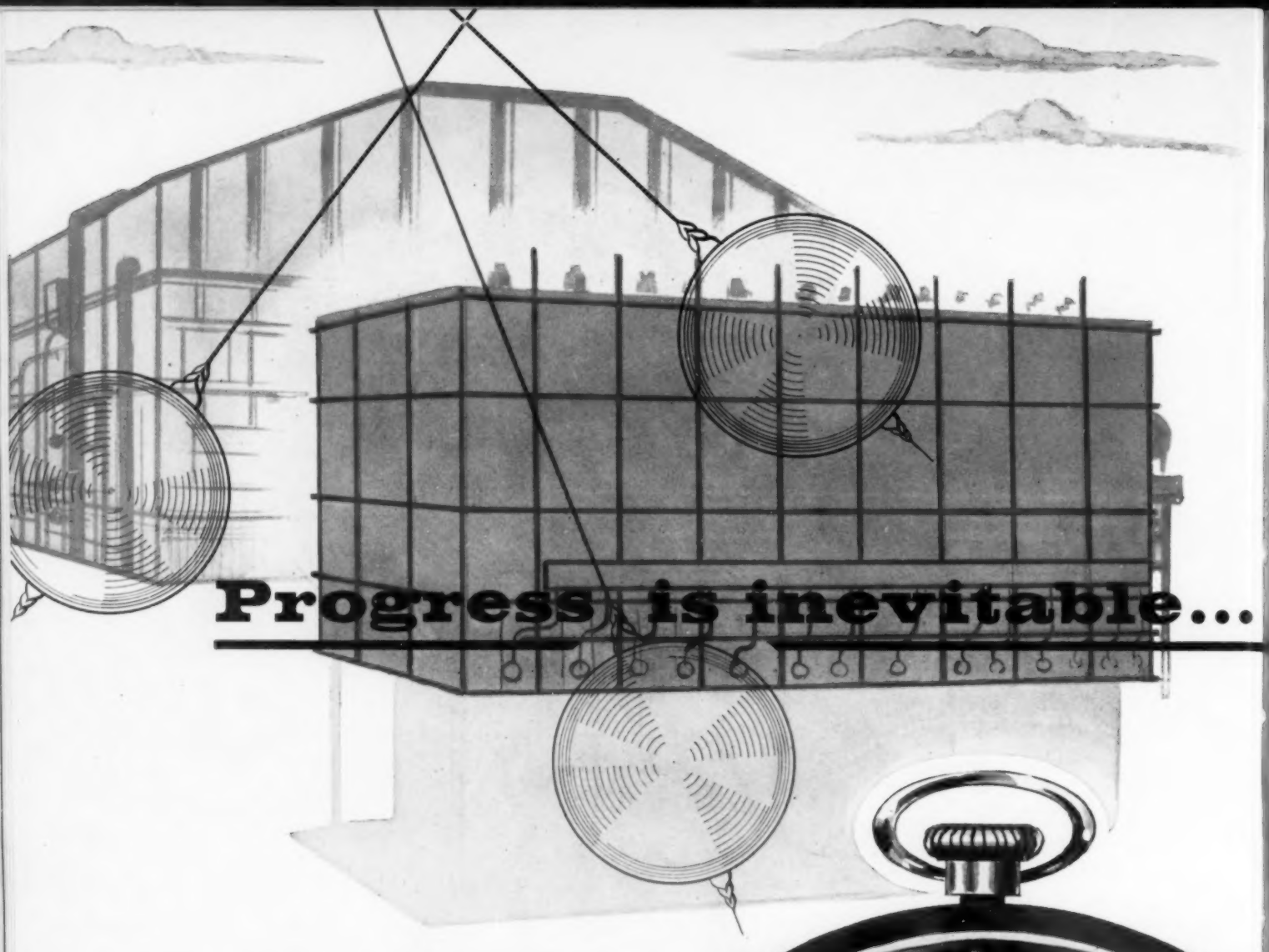
Paralleling developments in open hearth production since Samuel Wellman's first 5-ton furnace, Ironsides rolling mill lubricants have advanced far from the first heavy grease "shield," hand-paddled onto open gears. Encased gears now demand lubricants that can be poured, pumped and jetted. Free-running characteristics have become important in view of the enormous power consumption of today's big mills. At the same time, loads have increased until special Ironsides Shield is now being formulated for pressures as high as 25,000 psi. Shield for the roll necks is still being made of high melting point fatty base material, as it was 60 years ago, but is now formulated with close consideration to its pumpability. Water repellency, a consideration ever since the first rolling of hot steel, is of extreme importance in both roll neck and roller bearing shields.

In consequence, Ironsides engineers have become "custom tailors" of lubricants formulated for the specific conditions and preferences of the individual mill. They are accustomed to working closely with the superintendent, roller and lubrication engineer, on problems involving anything from a pail to tank car shipments.

If you have a problem, they'd like to help you lick it. Just address, or phone, The Ironsides Company, Columbus 16, Ohio.

By the makers of Palmoshield
"the palm tree that grows in Ohio"

Jos. MARGULIES.

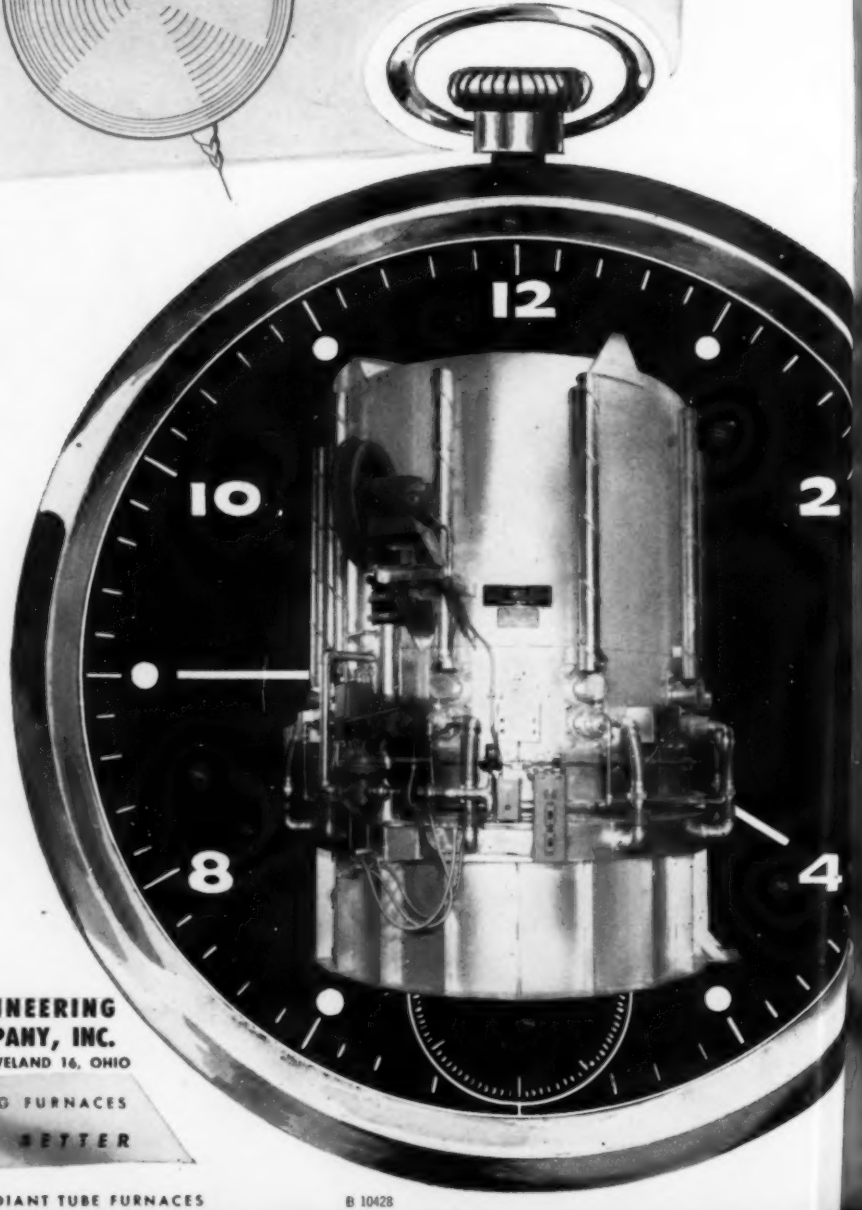


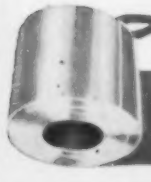
Progress is inevitable...

From eight-stack to four-stack —to single-stack . . . that's the way of progress in steel coil annealing.

Some years ago, larger steel producers were annealing in eight-stack furnaces. Then it was discovered they could actually get more work out at lower costs by reducing the size of the furnace to half. Now, these same devotees of high production are finding they can boost output per pedestal 50 per cent or more by reducing the furnace operation to a single stack of coils, and effect substantial savings in the bargain.

Wilson engineers have made great efforts to gather cost and efficiency data from leading mills for both single and four-stack installations. These reports prove beyond a doubt that a complete single stack installation is the fastest and least expensive to install, maintain and operate, with the quality which must result from truly *automatic* temperature control for every stack of coils.





Lee Wilson* **ENGINEERING COMPANY, INC.**

2000S WEST LAKE ROAD • CLEVELAND 16, OHIO

SINGLE-STACK RADIANT TUBE ANNEALING FURNACES

MAKE THE BEST METALS BETTER

* ORIGINATORS AND LEADING PRODUCERS OF SINGLE-STACK RADIANT TUBE FURNACES

B 10428

a few of the many types of
SPRAYING SYSTEMS CO.

spray nozzles

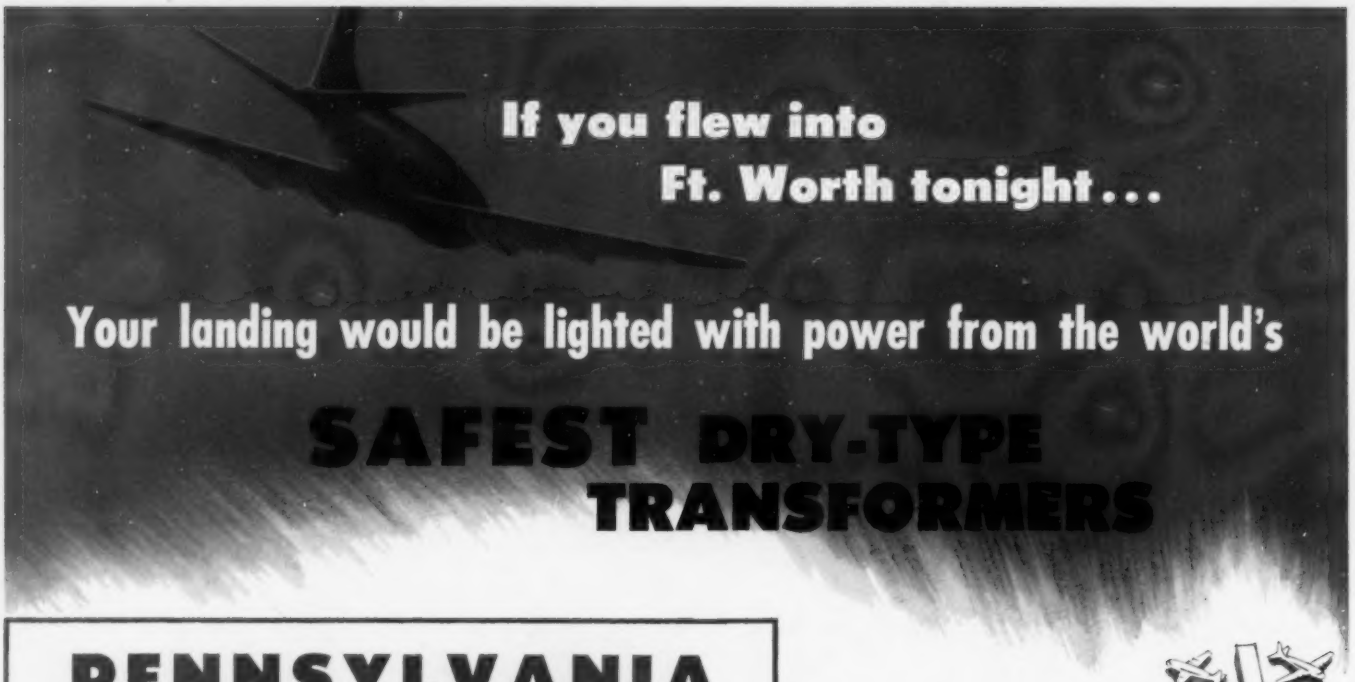
installed at the
Fairless Works

. . . for such operations as roll cooling on hot and cold mills • descaling • runout table cooling • pickling line • cooling slabs on transfer table • cooling ingot molds • cooling open hearth tunnels or checkers • cooling pigs • coke chemical processing • spraying lubricants • and air and gas washing

For every spraying operation, you will find Spraying Systems spray nozzles offer impressive, measurable advantages. That is why they have been so widely selected for application in the Fairless Works. Spraying Systems spray nozzles are made in a very wide range of types and sizes for exact performance to meet your specifications . . . products of America's leading designer and manufacturer of spray nozzles for industry. Your inquiry is cordially invited.

SPRAYING SYSTEMS CO.
3262 RANDOLPH STREET • BELLWOOD, ILLINOIS

Write for your FREE copy of new Catalog No. 24 . . . the most comprehensive spray nozzle catalog ever produced.



If you flew into
Ft. Worth tonight...

Your landing would be lighted with power from the world's

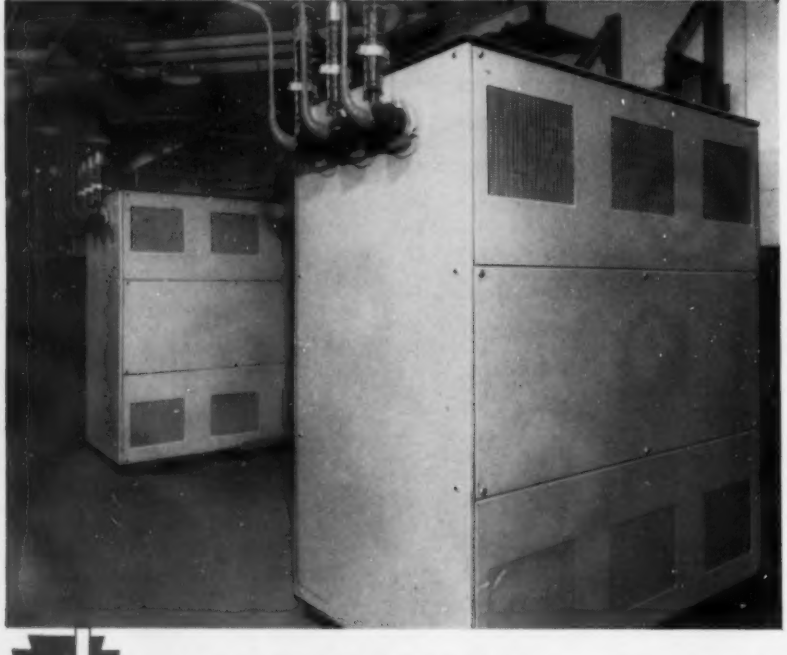
SAFEST DRY-TYPE
TRANSFORMERS

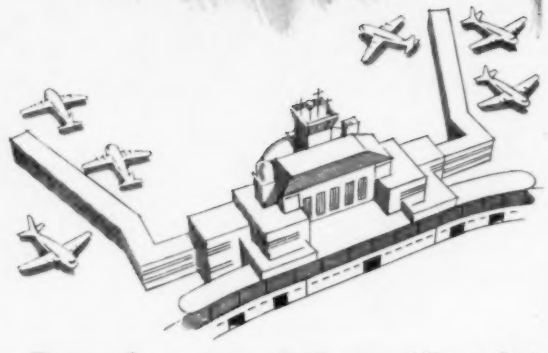
PENNSYLVANIA
Silicone-Insulated
TRANSFORMERS

at Greater Ft. Worth International Airport

are 1000-kva ventilated units, three phase, 60 cycles, 150 C. rise, 12470Y — 480Δ volts. Silicone-Insulated Transformers (formerly known as "Class H", now NEMA Group 3) were pioneered by Pennsylvania. The following types and sizes now are available:

TYPE	KVA	VOLTAGE
Ventilated	Up to 3000	Up to 15 kv
Sealed-in Nitrogen	Up to 2000	Up to 15 kv





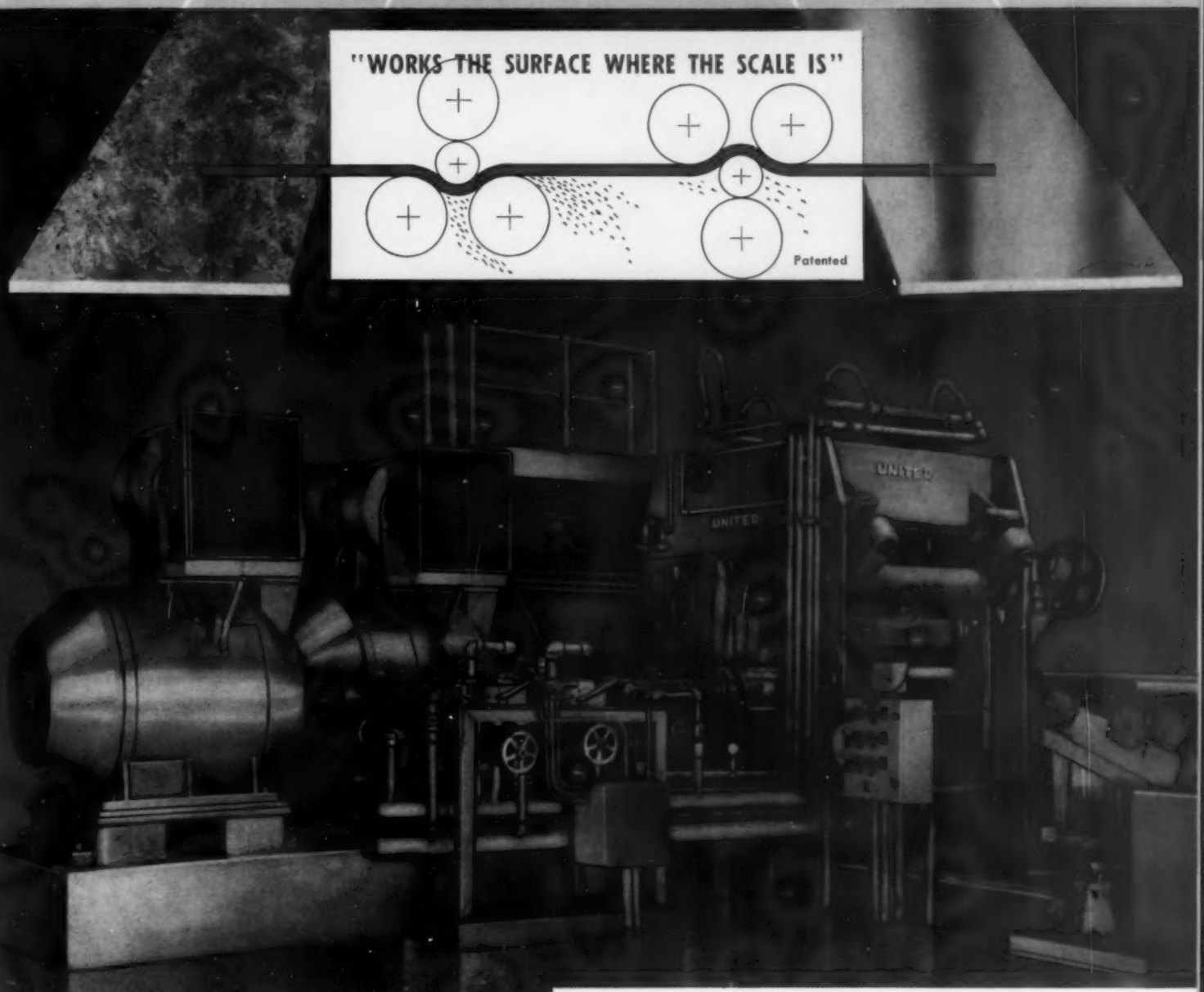
Power from two of the world's safest transformers — Pennsylvania *Silicone-Insulated* 150 C. Rise Transformers — would continue to light your way even after you stepped from the plane and entered the terminal building at Greater Ft. Worth International Airport. These two 1000-kva dry-type units are ideally suited for indoor installation because there is *no fire or explosion hazard* as with oil-filled transformers . . . *no risk from toxic fumes as* with Askarel units.

Also important, from the standpoint of public safety, is silicone insulation's *outstanding resistance to moisture* and other potential contaminants — one of the principal reasons for the trouble-free operating records of scores of Pennsylvania Silicone-Insulated units in service throughout the country. Such dependability — plus an *exceptional overload capacity* that can be called on in case of emergency — is of vital importance for the field and terminal lighting system at busy Ft. Worth International Airport.

PENNSYLVANIA TRANSFORMER COMPANY
A McGraw Electric Company Division **CANONSBURG, PA.** *Greater Pittsburgh District*

UNITED®

NEW *Strip Processing* SCALEBREAKER



1. The only SCALEBREAKER in which the degree of scale-breaking can be varied.
2. Assures faster, cleaner, less costly pickling and better finished product.
3. Easily installed in existing pickling lines.

Write today for complete engineering data.

UNITED ENGINEERING AND FOUNDRY COMPANY

PITTSBURGH, PENNSYLVANIA

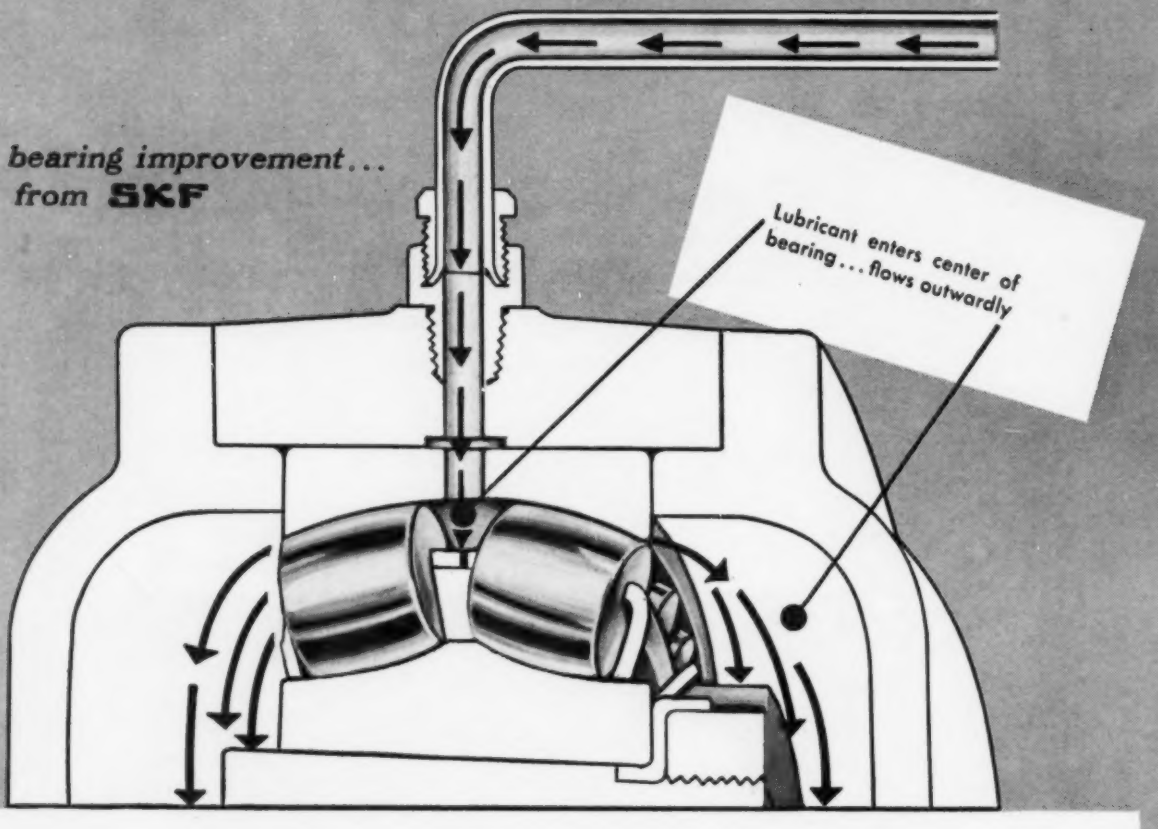
Plants at: Pittsburgh • Vandergrift • Youngstown • Canton • Wilmington (Lobdell United Division)

Subsidiaries: Adamson United Company, Akron, Ohio
Stedman Foundry and Machine Company, Inc., Aurora, Indiana

Designers and Builders of Ferrous and Nonferrous Rolling Mills, Mill Rolls, Auxiliary Mill and Processing Equipment, Presses and other heavy machinery. Manufacturers of Iron, Nodular Iron and Steel Castings and Weldments.

DETROIT PUBLIC LIBRARY

Another bearing improvement...
from **SKF**



NOW AT NO EXTRA CHARGE-

SKF's improved method of lubricating large spherical roller bearings

To make the lubricant effective it should be located where needed—in the bearing. Also, new lubricant, when added, should enter where it does the most good—in the bearing.

For these reasons, all future production of SKF double row spherical roller bearings above 240 mm O.D. (9.4488") will be made with three equally spaced drilled holes in the center of the outer ring without any extra charge to our customers. *This permits the lubricant to enter the center of the bearing.*

With the lubricant (either grease or oil) being introduced into the center of the bearing, all working surfaces are quickly and completely covered. In addition, the outward flow flushes out the old lubricant, and with it, any abrasive dust, dirt, moisture or other impurities.

And where circulating oil lubrication is required, there is a continuous flushing and cooling of the bearing.

This is another example of how SKF helps you to obtain longer bearing life.

7711

Consult your SKF District Office today for complete information so that you can be the first to incorporate into your products this improved method of lubricating large spherical roller bearings.

SKF®

BALL AND ROLLER BEARINGS

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.
—manufacturers of **SKF** *and* HESS-BRIGHT® *bearings.*

Delivering semi-finished steel to outside storage by Ross Carrier—Kaiser Steel Corp., Fontana Works, Fontana, California.

Here's production flow ingenuity...

Kaiser Steel's 1 2 3 Operation!

1 A foreman calls for material over a two-way radio.

2 Immediately a Ross Carrier rushes into action . . . locates the material.

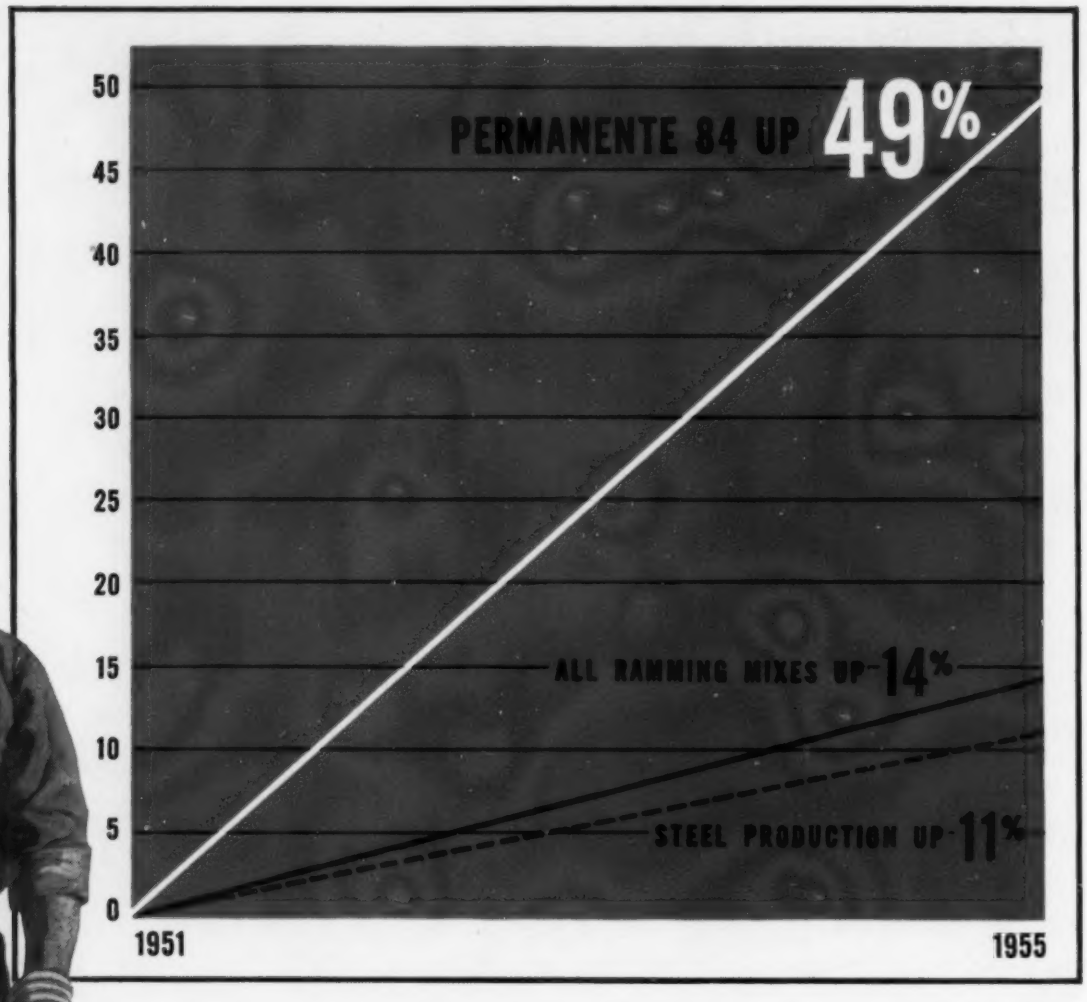
3 Loaded in seconds, the Ross Carrier is on its way to delivery.

No hold-up of production flow at Kaiser Steel. Blooms and slabs of semi-finished steel are rushed at a moment's notice to specialty mills for treatment. Four highly maneuverable Ross Carriers, equipped with two-way radio, have greatly reduced rail hauling within the plant site . . . have made operations between conditioning yards, storage yards and the mills, a fast, *modern* operation.

CLARK® EQUIPMENT

Industrial Truck Division CLARK EQUIPMENT COMPANY, Battle Creek 135, Michigan

FREE—a 16-page idea book! Gives you 21 industrial applications of the Ross Carrier—profitable ideas that you can use in your own business. Just tear out this coupon and attach to your letterhead. We'll rush you a copy with no obligation.



Why this growing preference for Permanente 84 Ramming Mix!

As you can see from the chart above, sales of all ramming mixes to steel producers increased only 14% during the five year period ending December 31, 1955.

But during this same period, sales of Permanente 84 Ramming Mix increased *a whopping 49%*!

Why is Permanente 84 increasingly preferred by leading steel producers?

Briefly, here are the reasons:

Permanente 84 reduces the cost of maintaining furnace bottoms and banks. Repairs made with Permanente 84 stay put! Down time for hot-repairs is reduced because repairs made with Permanente 84 last longer. Steel production goes up—costs come down. Ideal for hot patching both open hearths and electric furnace banks and bottoms.

Order Permanente 84 now, and get extra steel tonnage at lower cost.

Kaiser Chemicals Division, *Kaiser Aluminum & Chemical Sales, Inc. Regional Sales Offices: 1924 Broadway.* OAKLAND *12, California . . . 3 Gateway Center,* PITTSBURGH, *Pennsylvania . . . 518 Calumet Building, 5231 Hohman Avenue, Hammond, Indiana* (CHICAGO).

Kaiser Chemicals

Pioneers in Modern Basic Refractories

Refractory Brick and Ramming Materials • Castables & Mortars • Magnesite • Periclase • Deadburned Dolomite

By MELVIN NORD, Patent Attorney, Detroit, Mich.

Patent Reviews

. . . . copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents . . . . patents reviewed cover period February 7, 1956 through February 28, 1956.

BLAST FURNACE LININGS

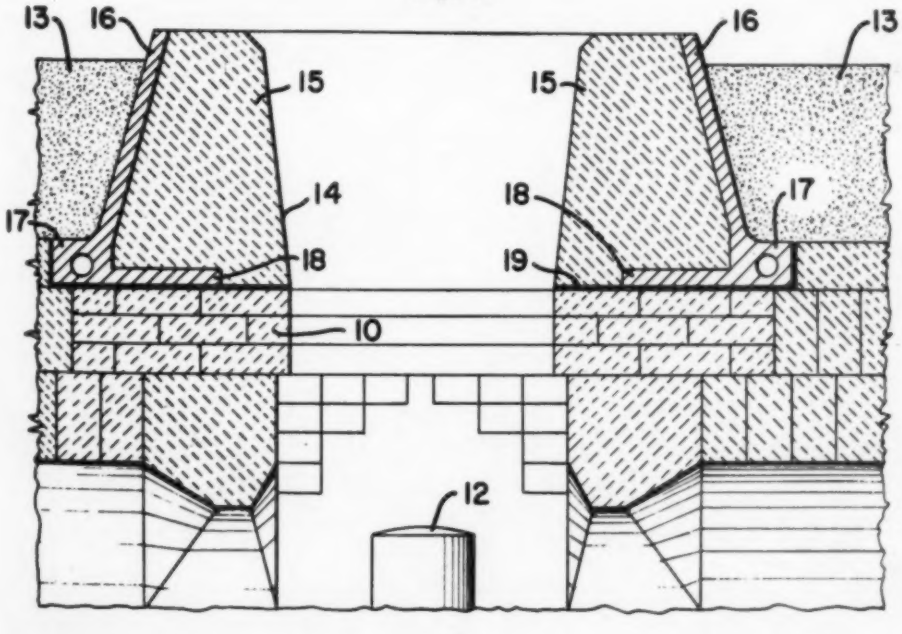
▲ U.S. 2,733,913, issued Feb. 7, 1956 to George E. Mercer, relates to linings for pig iron-producing blast furnaces, and has as its object increasing the life of the lining.

The refractory used is low in ferric oxide and is of such a nature that it will not take on ferric oxide. When carbon monoxide reacts with the ferric oxide in ordinary fire clay linings, free carbon is produced which accumulates and disintegrates the lining structure.

The bottom of the crucible is lined with high alumina brick of low porosity. The walls of the crucible and bosh are lined with high fusion hard burned mullite brick. Starting at the mantle and upwardly, a high fusion alumina brick of low porosity is used for the lower inwall and a high fusion silicon carbide brick lining for the lower portion of the upper inwall section. A similar mullite brick is used for the upper portion of the upper inwall. The bell zone is lined with fire clay brick.

The lining specified not only avoids the description of the refractory by the formation of carbon in it, but also avoids other faults such as erosion or the production of scabs on the refractory wall. It is also claimed that the thickness of the lining can be reduced from sixty inches to twenty-seven inches. Not only is the life of the lining increased, but the capacity of the blast furnace is also mechanically increased in this way.

Figure 1



PICKLING PROCESS

▲ U.S. 2,733,999, issued Feb. 7, 1956 to Clarence J. Rodman and assigned to Alliance Ware, Inc., describes a process of pickling and coating iron sheet products with a thin coating of metal prior to enamelling.

According to the invention, the sheet metal products are both pickled and coated with the metal in the same bath. The operation is carried out as a continuous process, and the conveyor which carries the sheet metal products through the treating bath supplies the metal for coating.

LINING FOR SOAKING PIT BURNER PORTS

▲ U.S. 2,734,734, issued Feb. 14, 1956 to Fredrick L. Knight and assigned to United States Steel Corp., provides improved linings for burner ports in bottom-fired soaking pits.

Figure 1 shows a portion of the soaking pit which includes a bottom 10 of refractory brickwork and a burner 12. The bottom brickwork carries a layer 13 of loose granular material, such as coke breeze, and it contains a port 14 directly above the burner. The port lining consists of an annular monolithic refractory body 15 and a surrounding metal form 16. The refractory body is preferably of rammed plastic chrome ore which fuses to a monolithic mass at the furnace temperature. The metal form 16 has lifting lugs 17 and an exterior flange 18 at the bottom. The flange terminates short of the inner surface of the refractory body so that it does

not burn away. Between the upper surface of the brickwork 10 and the bottom of the metal form 16 and refractory body 15, there is a thin layer of antiwelding material such as dry chrome ore, which assures that the port lining can be lifted easily from the bottom brickwork 10.

VACUUM POURING APPARATUS

▲ U.S. 2,734,240 and 2,734,241 issued Feb. 14, 1956 to Raymond L. Southern and James K. Ely, assigned to Allegheny Ludlum Steel Corp., describe a process and apparatus for vacuum treating molten metal as it is poured into a mold.

As shown in Figure 2, the apparatus consists of a tundish 18, a holding unit 20, a vacuum chamber 22, and a valve structure 24 on which the ladle 14 is mounted.

The tundish 18 is formed of refractory material 26 within metallic walls and base 28, and has a teeming storage well 30 and a runner 32. The tundish may be rotated by an indexing mechanism 38, so as to direct the flow of molten metal from the tundish to a predetermined mold 16.

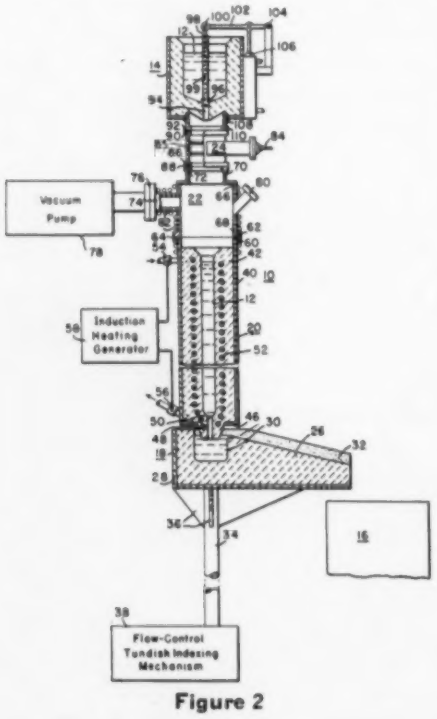


Figure 2

An induction coil 52 is embedded in the refractory material of the holding unit 20, in order to prevent freezing of molten metal in the holding unit or in the orifice 50 of the nozzle 48.

The initial flow of the metal down through the apparatus is at a rapid rate until the teeming storage well 30 is filled. The orifice 50 then restricts the flow and builds up a level of molten metal in the holding unit 20. The height of molten metal in unit 20 is sufficient to act as a seal from the atmosphere, thus permitting the molten metal to be degassed as it flows from the ladle 14 down through the vacuum unit 22.

A vacuum of 50 microns is needed in the vacuum chamber in order to remove oxygen and nitrogen practically completely. Some hydrogen is also removed.

INGOT MOLDS

▲ U.S. 2,734,242, issued Feb. 14, 1956 to Edgar Marburg and assigned to United States Steel Corp., describes modified forms of ingot molds which tend to cool the bottom and middle of the mold faster than the top, thereby minimizing pipe and V-segregation.

A thickened portion of the mold, in the form of a ring at about the mid-height of the mold, and a reduced wall thickness below this (in the form of another ring) constitute the changes in the conventional mold design.

TEAR DETECTING AND INDICATING MEANS FOR SHEET METAL

▲ U.S. 2,735,329, issued Feb. 21, 1956 to Fredrick A. Meunier and assigned to Republic Steel Corp., relates to the detection and removal of defects in the margin of sheet steel, i.e. to small tears or cracks extending inward from the edge of the strip.

In one form of the invention, an automatic machine detects tears and marks the strip to indicate their location, so that they can be removed manually. In another form, the defective portions are automatically cut out. The tear detection is accomplished by photoelectric means, light passing through the tears activating a phototube controller.

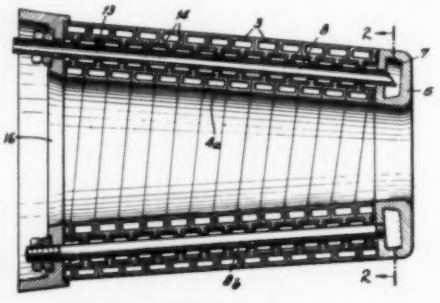


Figure 3

TUYERES FOR BLAST FURNACES

▲ U.S. 2,735,409, issued Feb. 21, 1956 to Bruno Aurin and Willi Dehne, assigned to Herr Ernst Thomas, describes a water-cooled tuyere for blast furnaces.

As shown in Figure 3, the outer surface of the tuyere is formed of a spirally wound tube 3, and the inner

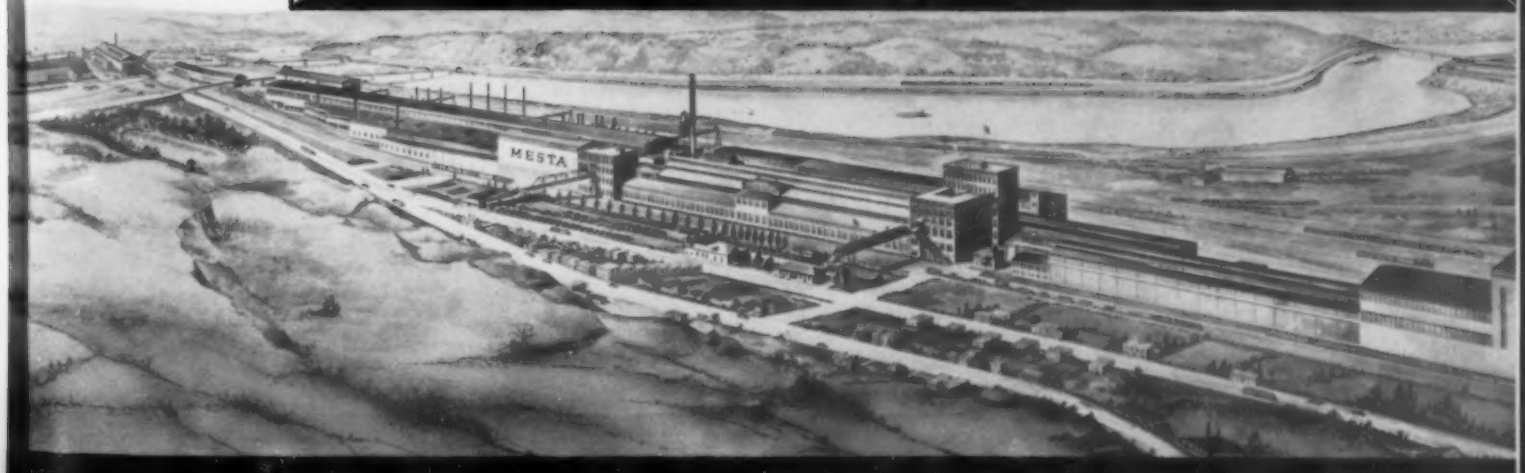
OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,733,500	2/ 7/56	Method of making a plowshare blank	Jones & Laughlin Steel Corp.
2,733,908	2/ 7/56	Recuperator tube tile structure	Amsler Morton Corp.
2,734,244	2/14/56	Refining and melting titanium	Allegheny Ludlum Steel Corp.
2,734,406	2/14/56	Bearing assembly for rolling mill	Morgan Construction Co.
2,734,551	2/14/56	Apparatus for prevention of coil breaks	United States Steel Corp.
2,734,570	2/14/56	Flying shears having preselected miss-cut action	The Hallden Machine Co.
2,734,738	2/14/56	Cupola tuyere gates with integral downward deflectors	Nicholas Even
2,734,818	2/14/56	Making stainless steel castings in a reverberatory furnace	Carl G. de Laval, Jr.
2,735,163	2/21/56	Composite magnesium-iron articles	The Dow Chemical Co.
2,735,536	2/21/56	Apparatus for centering a strip	United States Steel Corp.
2,735,557	2/21/56	Coke extractor for vertical retort	West's Gas Improvement Co. Ltd.
2,736,217	2/28/56	Adjusting device in rolling mills	Societe Anonyme des Acieries at Forges de Firminy
2,736,405	2/28/56	Connector for flanged sheets abutting endwise	United States Steel Corp.
2,735,429	2/28/56	Hot extrusion of metals	Comptoir Industriel d'Etirage et Profilage de Metaux
2,736,431	2/28/56	Sheet pin hole detector	United States Steel Corp.
2,736,504	2/28/56	Roll crushing mill for crushing coke fines	Koppers Co., Inc.
2,736,648	2/28/56	Low metalloid enameling steel	United States Steel Corp.
2,736,649	2/28/56	Ferritic stainless steel	United States Steel Corp.
2,736,650	2/28/56	Low alloy high speed steel	Firth Sterling, Inc.
2,736,673	2/28/56	Method of making an axle	United States Steel Corp.
2,736,699	2/28/56	Cold working lubricant for wire	United States Steel Corp.

DESIGNERS
and BUILDERS
of Complete
STEEL PLANTS

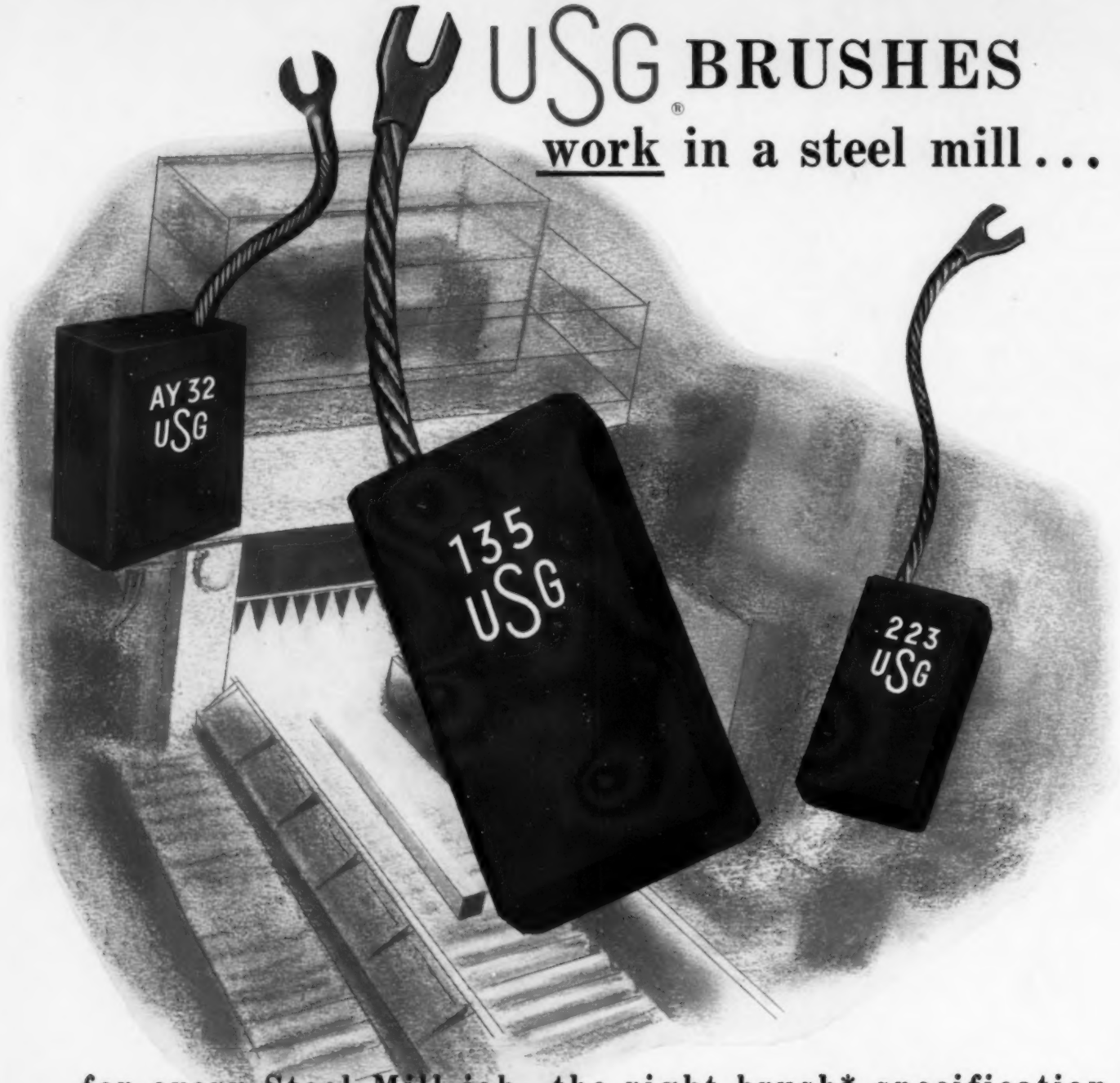
MESTA

THERE IS NONE BETTER



MESTA MACHINE COMPANY
PITTSBURGH, PENNSYLVANIA

USG® BRUSHES
work in a steel mill...



for every Steel Mill job—the right brush* specification

THE JOB	THE BRUSH
Mill Motors	USG Grade 135
DC Crane Motors	USG Grade 223
Diesel Main Generators	USG Grade AY 32 or 2306
Diesel Switcher Traction Motors	USG Grade 2207
Welding Generators and Exciters	USG Grade AH 897
Tin Line Collector Rolls	USG Grade 1658
Tin Line Generators	Grade on request
Cleaning Line Generators	Grade on request
DC Generators (DC Power Supply)	USG Grade 232
AC Crane Motor Slip Rings	USG Grade 550

*All USG brushes can be obtained with STATITE®, the permanent shunt connection, needing no hammerclips; cannot be jarred loose or pulled out.

Write for your copy of the complete USG Brush Catalog.

211

THE UNITED STATES GRAPHITE COMPANY
DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

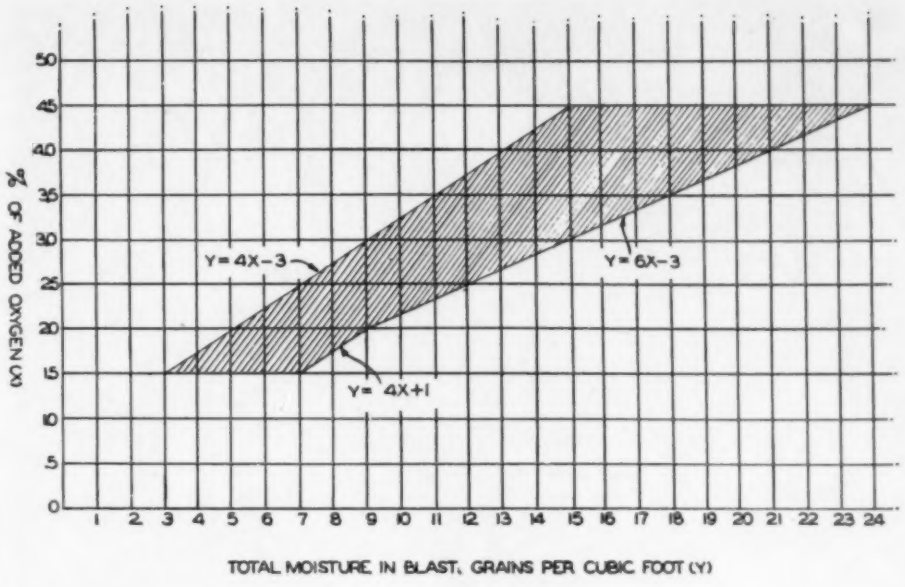


Figure 4

surface of a spirally wound tube 4 a. Each tube has legs 13, between which are wound spiral bands 14 of steel or copper. Water flows through the two tubes in series.

MANUFACTURE OF IRON POWDER

▲ U.S. 2,735,757, issued Feb. 21, 1956 to Heinz G. G. Zapf and assigned to Husqvarna Vapenfabriks Aktiebolag, describes a low-cost method of producing iron powder suitable for pressing and sintering.

Iron scrap, such as turnings, is dissolved in hydrochloric acid. After filtration or centrifuging, air is blown into the resulting solution, precipitating a portion of the iron in the form of finely dispersed ferric hydrate. After filtration or centrifuging, the hydrate is washed and dried, and then reduced to iron powder with a reducing gas. The filtrate from the precipitation step is then re-used for dissolving more iron scrap.

OPERATION OF BLAST FURNACES

▲ U.S. 2,735,758, issued Feb. 21, 1956 to Julius H. Strassburger and assigned to National Steel Corp., describes the operation of blast furnaces utilizing an oxygen-rich blast, in which controlled additions of moisture are added. The addition of oxygen to the blast causes the furnace to tend to run cold, while the water enters into an exothermic reaction with carbon in the hearth, thereby transferring heat from the hearth up the stack.

According to the inventor, optimum conditions are obtained when the relation between added oxygen and moisture in the blast are within the shaded region of Figure 4.

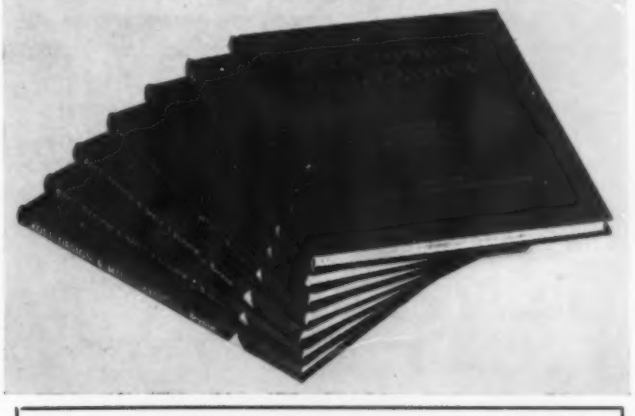
POSITIONER AND DRIVE FOR BLAST FURNACE DISTRIBUTOR

▲ U.S. 2,736,440, issued Feb. 28, 1956 to Charles Steckle and Roy L. Wingenroth, and assigned to United States Steel Corp., provides a positioner and drive for a blast furnace distributor, which is capable of maintaining the parts in alinement despite wear.

Revised and rearranged collection of articles which appeared in the Iron and Steel Engineer between 1943 and 1950 . . . a book for rolling mill men and for anyone interested in rolling mills and roll design . . . written from a practical viewpoint by one who has had considerable experience in the art of roll design.

ROLL DESIGN
and
MILL LAYOUT

By
ROSS E. BEYNON



Cloth bound . . . 128 pages . . . 330 illustrations

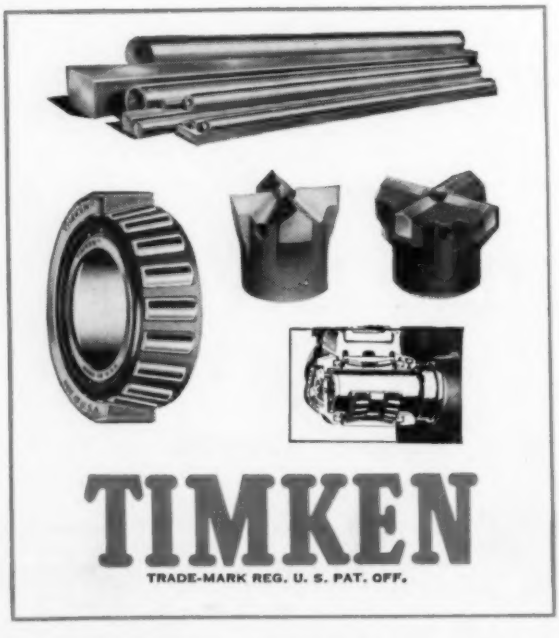
Price: To AISE Members . . . $3.00
To Others $5.00

ASSOCIATION OF IRON AND STEEL ENGINEERS
1010 Empire Building Pittsburgh 22, Pa.

You mean what you say, when you say "TIMKEN"

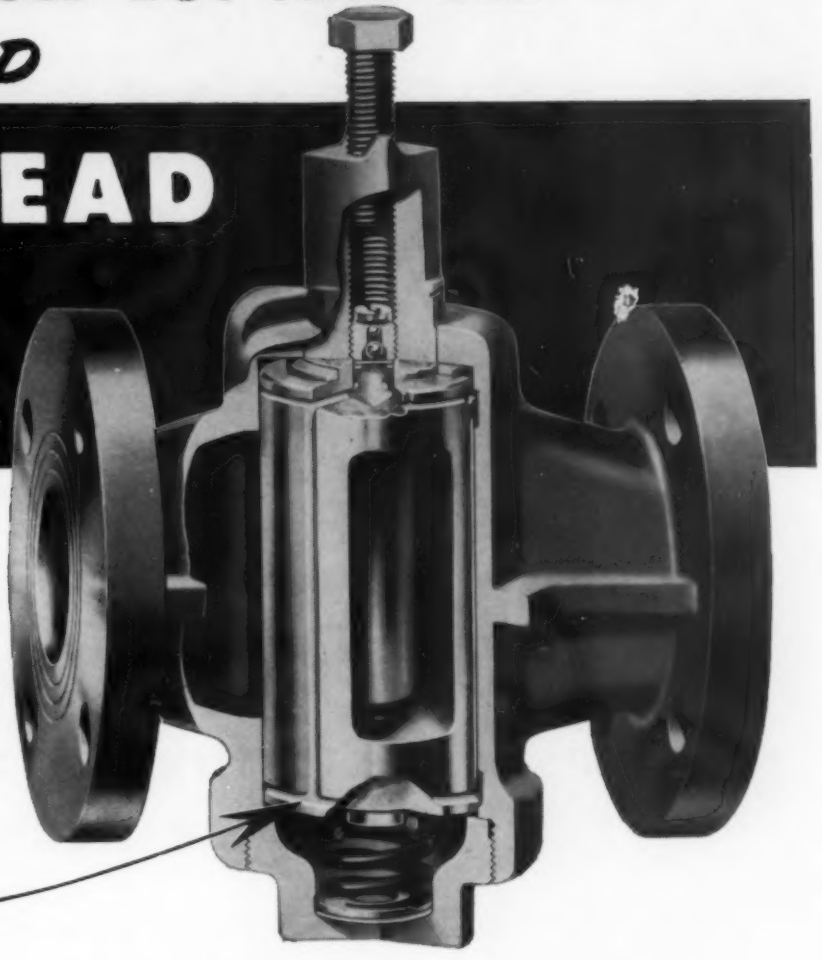
IF you are content with just any old kind of tapered roller bearing, steel or rock bit, of course you don't specify "Timken". By the same token, when you want highest quality you don't specify anything *but* "Timken". To make sure you get what you want—to safeguard your reputation and ours—we stamp "Timken" on every product we make. When you say "Timken" we know you *mean* a product made by the Timken Company . . . because, as everyone is aware, "Timken" is a trade-mark, not *just a type of product.*

When you purchase tapered roller bearings, alloy steel bars, seamless steel tubing or removable rock bits, always look for this famous legal identification. When you see it, you know there are over 55 years of experience behind it. When you *say* it, you're saying exactly what you mean: "I want the best." The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".



TAPERED ROLLER BEARINGS • REMOVABLE ROCK BITS • FINE ALLOY STEELS

No. 5* of 12 REASONS WHY
YOU SHOULD BUY AND USE
LOW-PRICED
HOMESTEAD
Lubricated
PLUG VALVES



***SELF-FREEING PLUG PREVENTS STICKING**

Homestead's exclusive completely controlled lubricant system positively prevents sticking by its instant, piston-like movement of the plug downward at the start of each lubrication. Spring and line pressure return it to stem-sealed position.

This is only **one reason why you should buy and use low-priced** HOMESTEAD LUBRICATED PLUG VALVES.

HERE ARE ALL TWELVE

1. Extra long valve life assured by very close tolerance between sealing surfaces.
2. Straight line fluid flow—streamlined ports—minimum resistance to flow—minimum pressure drop.
3. Triple head seal—two lubricant rings and reinforced Teflon stem seal prevent leakage.
4. Easy turning—plug floated on Teflon washer and reinforced Teflon ring.
5. Self-freeing plug prevents sticking.
6. Full-threaded screw prevents dirt being forced into lubricant system.
7. Quarter-turn fully opens or closes.
8. Reinforced Teflon stem seal—no cold flow—continuous, positive seal.
9. Seating surfaces protected in both open and closed positions.
10. High pressure lubricant system provides full lubricant seal around ports.
11. Leak-proof double ball and lubricant sealed check valve. No springs. No maintenance.
12. Two lubricants handle most services.

FOR CATALOG AND COMPLETE DETAILS MAIL COUPON TODAY

HOMESTEAD
VALVE MANUFACTURING COMPANY
"Serving Since 1892"

P. O. Box 21 **Coraopolis, Pa.**

Without obligation, send Reference Book 39—Section 5 on HOMESTEAD LUBRICATED PLUG VALVES.

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

It's in the Bag!

Fresh, Clean Ink for a Year of Trouble-free Recording

★ You won't have any messy, time-consuming re-inking of pens on the new Bailey Recorders. The entire system is white-glove clean—hermetically sealed, non-evaporating, non-corrosive. Gone is any chance of sludge or oxide formation. Gone are clogged pens, interrupted records, unsightly splashes.

The transparent plastic ink sacs are changed once a year—that's all. Capillary tubing carries fresh, clean ink to the pens continuously without any day-to-day attention.

This exclusive new inking system* is only one of the many time-saving, money-saving distinctive features of the new Bailey Recorder.

Ask for Product Specification E12-5. P34-1

*Now available for the New Bailey Recorder only.

ONLY BAILEY OFFERS ALL THESE ADVANTAGES IN A SINGLE RECORDER

- Pre-calibrated plug-in receiver units
- Up to four pneumatic or electronic receivers —or two receivers and two integrators
- Any four variables on one chart—easily read and interpreted
- A full year's ink supply at one loading
- Faster ordering—from stock
- Minimum inventory of parts
- Minimum instrument investment for process cycle expansion or alteration

BAILEY METER COMPANY
1047 IVANHOE ROAD
CLEVELAND 10, OHIO
Controls for Power and Process

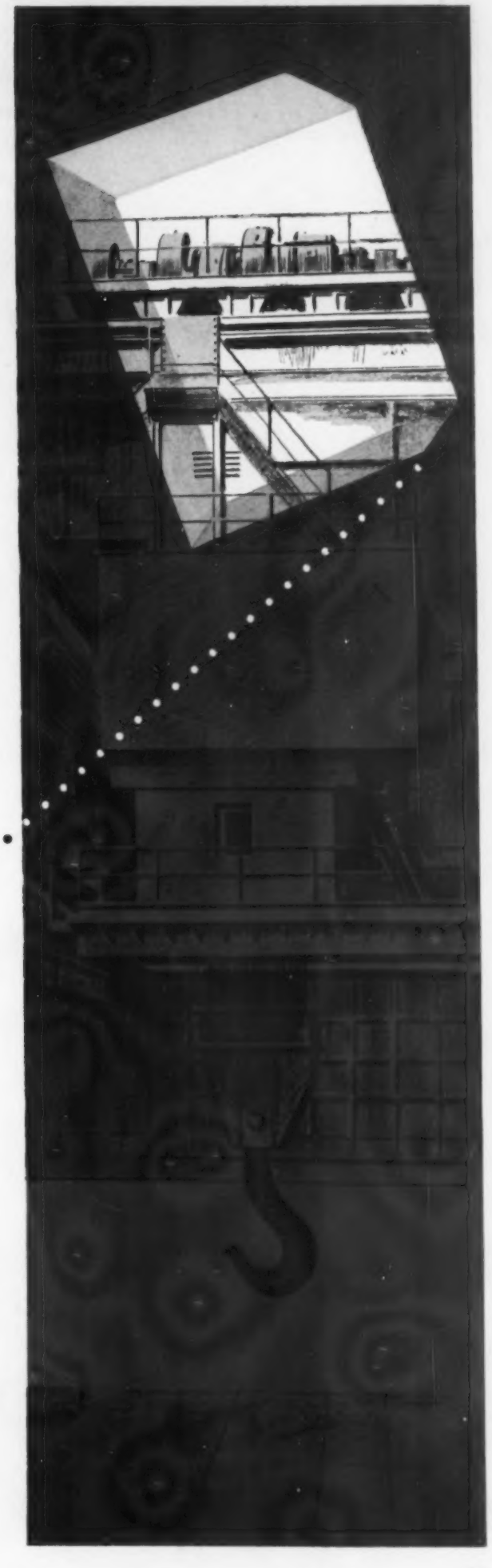
BAILEY METERS
Controls for
TEMPERATURE
PRESSURE
GAS ANALYSIS
FLOW · LEVEL
RATIO · DENSITY

Why NATIONAL TRADE-MARK *brushes are best for*

CRANE AND HOIST MOTORS

Each Brush in the complete line of "National" brushes is compounded to meet a specific set of operating conditions. Together, these service-proved "National" brush grades provide a proper choice for every application in your mill or mine.

For Example, the following "National" brushes are recommended for crane and hoist service, as indicated. They are the finest brushes money can buy ... so much the best for these services that you will find they actually save you money in over-all cost of operation.



GRADES AX-5, TA-35, TA-45 and 401

These are standard grades with long service-records; application is in accordance with machine design.

GRADES 850 and N-4

Grade N-4 is highly efficient in handling alternate extremes of light and heavy loading; grade 850, for open-hearth ladle, soaking pit cranes and severe hoist conditions.

Be Certain of your brush selections. Get the recommendations of a "National" brush specialist to assure top performance and long life of costly equipment.

The term "National", the Three Pyramids Device and the Silver Colored Cable Strand are registered trade-marks of Union Carbide and Carbon Corporation

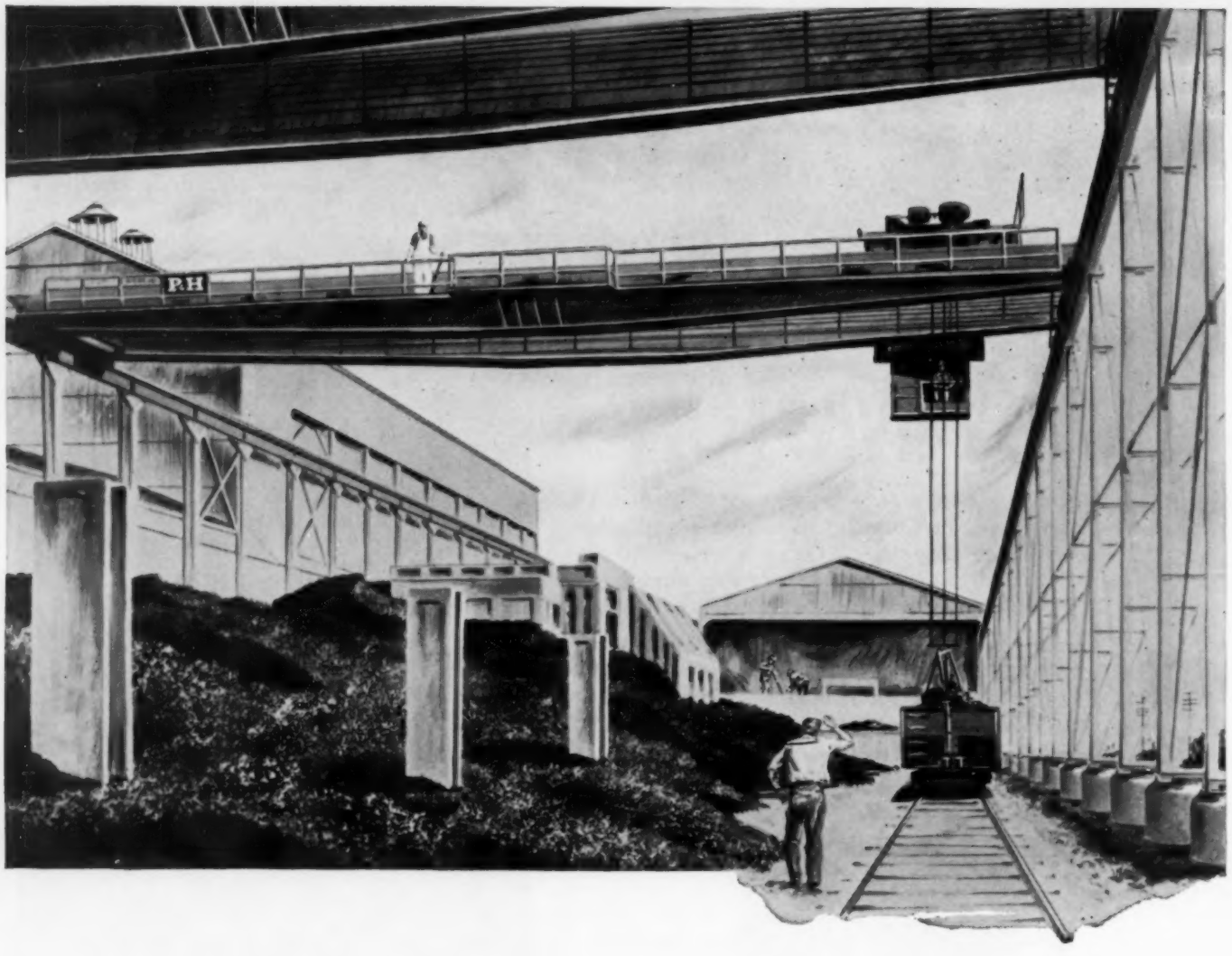
NATIONAL CARBON COMPANY

A Division of Union Carbide and Carbon Corporation

30 East 42nd Street, New York 17, N.Y.

SALES OFFICES: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco

IN CANADA: Union Carbide Canada Limited, Toronto



Experience

...is only one reason P&H Overhead Cranes outsell every other brand on the market

Ask a user why he bought a P&H Overhead Crane. Chances are he'll say: "Well, P&H has been making them for 72 years. They ought to know how to turn out a good serviceable crane by now."

We do. And part of the reason we do is because we make every part of a P&H Overhead Crane right in our own factory. From gigantic steelwork down to the tiniest electric control — it's all P&H made.

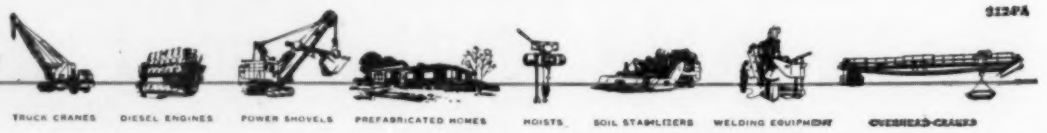
What this means to you is that there's a wealth of coordinated experience behind every part in your P&H Overhead Crane. It means that every part is made right—so that you have a smoother-running, more efficient piece of equipment.

Plus our experience in making them, there's also the 72 years of experience our customers have had in using them. Take either experience as a recommendation and you can't go wrong.

HARNISCHFEGER

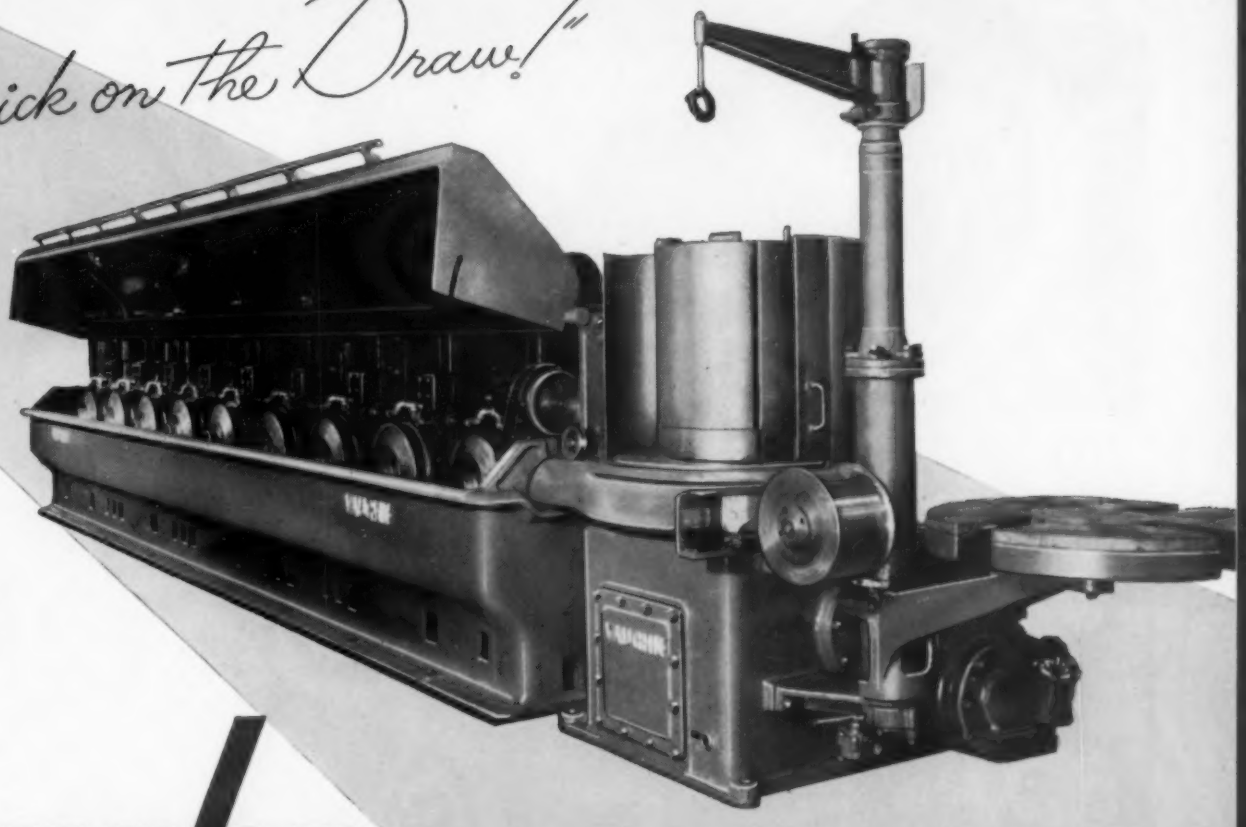
MILWAUKEE 46, WISCONSIN

the P&H Line



3124PA

"Quick on the Draw!"



Vaughn® HEAVY TANDEMS

for rapid size reduction of large-diameter rod in copper and alloys

Top efficiency is reached in reducing larger rod diameters with Vaughn slip-type, wet drawing heavy tandems. • Our standard tandems provide high speed reduction of ⅜" diameter aluminum and 5/16" copper to wire • Let us discuss the types and sizes of interest to your operations.

STANDARD TANDEMS

for high-speed drawing of aluminum and copper rod to wire sizes

The Vaughn MACHINERY COMPANY • CUYAHOGA FALLS, OHIO • U.S.A.

COMPLETE COLD DRAWING EQUIPMENT—Continuous or Single Hole . . . for the Largest Bars and Tubes . . . for the Smallest Wire . . . Ferrous, Non-Ferrous Materials or their Alloys.

Bearings, Inc.

Cuts Waiting Time for Replacement Bearings...

How? . . . By having as complete as possible stocks of all bearings in the branch near you . . . By complete, up-to-date records of every bearing held by all 28 of our branches and the facilities to ship to any point immediately . . . By working closely with the manufacturers of all bearings to expedite delivery of bearing sizes and types not in plentiful supply. Bearings, Inc. Sales Engineers are always "on call" to solve bearing replacement problems. There's a stock carrying branch near you — Get to know our sales engineers and how they can be reached 24 hours a day — know the services Bearings, Inc. have for you and waiting time for bearings will be no problem!

BEARINGS, INC.
3634 Euclid Ave.
Cleveland 15, Ohio

Gentlemen:

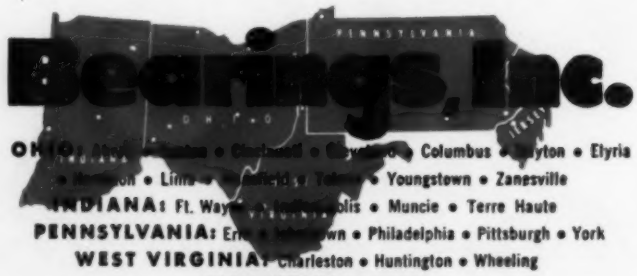
I'd like to have the night and emergency phone numbers of your branch nearest our plant.

Name.....

Firm.....

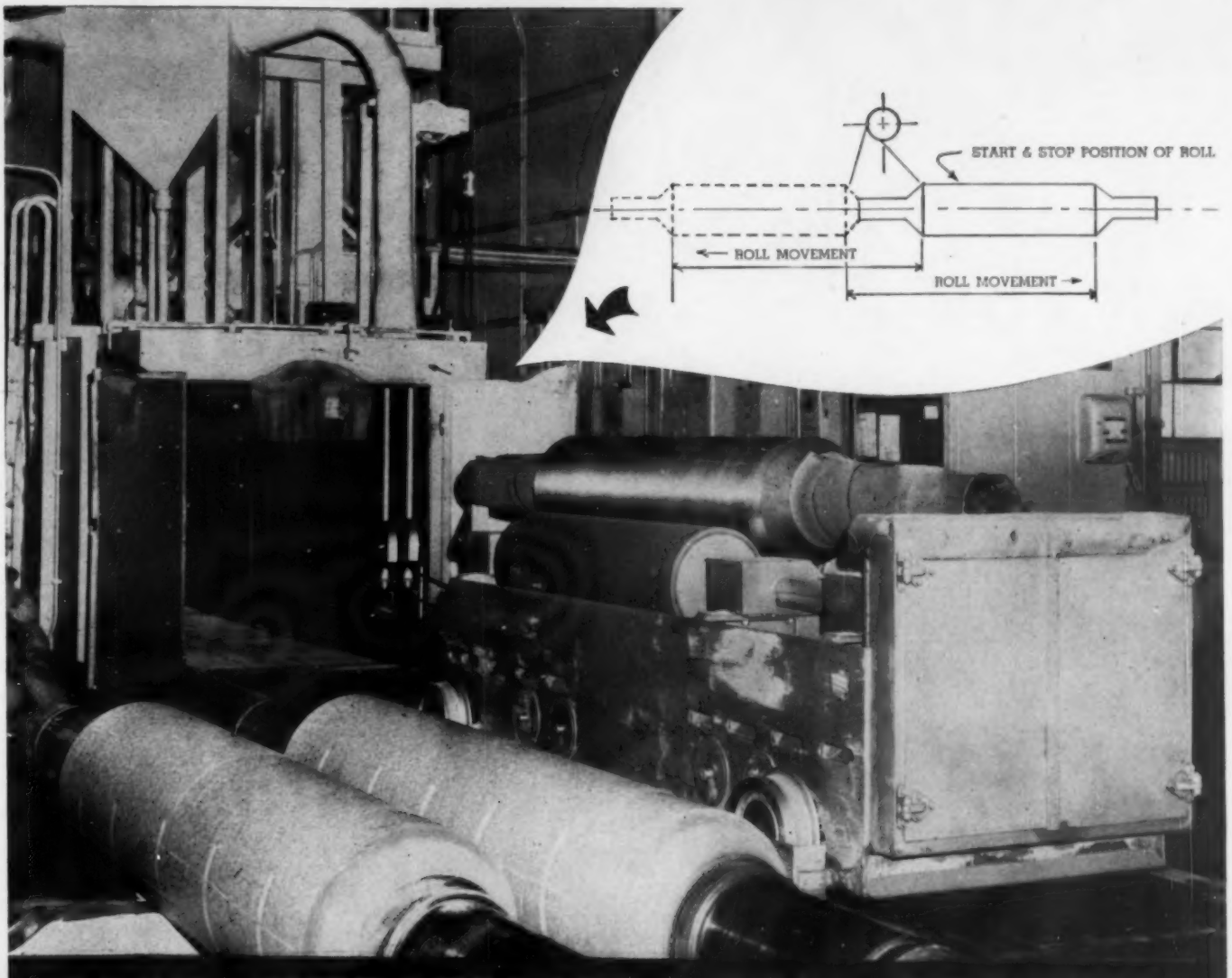
Address.....

City.....Zone.....State.....



Bearings, Inc.

OHIO: [illegible] • Cleveland • [illegible] • Columbus • [illegible] • Elyria • [illegible] • Lima • [illegible] • Toledo • Youngstown • Zanesville
INDIANA: Ft. Wayne • [illegible]olis • Muncie • Terre Haute
PENNSYLVANIA: Erie • [illegible]wn • Philadelphia • Pittsburgh • York
WEST VIRGINIA: Charleston • Huntington • Wheeling
NEW JERSEY: Camden
Subsidiary: Kentucky Ball and Roller Bearing Co. • Louisville, Ky.



FAST, UNIFORM MILL ROLL ETCHING IS AUTOMATIC WITH A *WHEELABRATOR*®

Compare your mill roll etching time with this actual performance of an airless Wheelabrator: Rolls up to 9 inches in diameter in 54 seconds; rolls up to 27 inches etched in 3 minutes.

And Wheelabrator gives a uniform etch because the roll rotates and moves laterally at uniform speed as it passes under the entire blast pattern in both directions as indicated in the sketch above. You never get any "barber pole" effect with a Wheelabrator.

Completely automatic, the machine requires no special skill or judgment by the operator, and the finish obtained is extraordinarily deep and uniform, even for the hardest rolls. This depth and uniformity extend roll life as much as 35% and products processed on the rolls receive an etch that is deep and uniform.

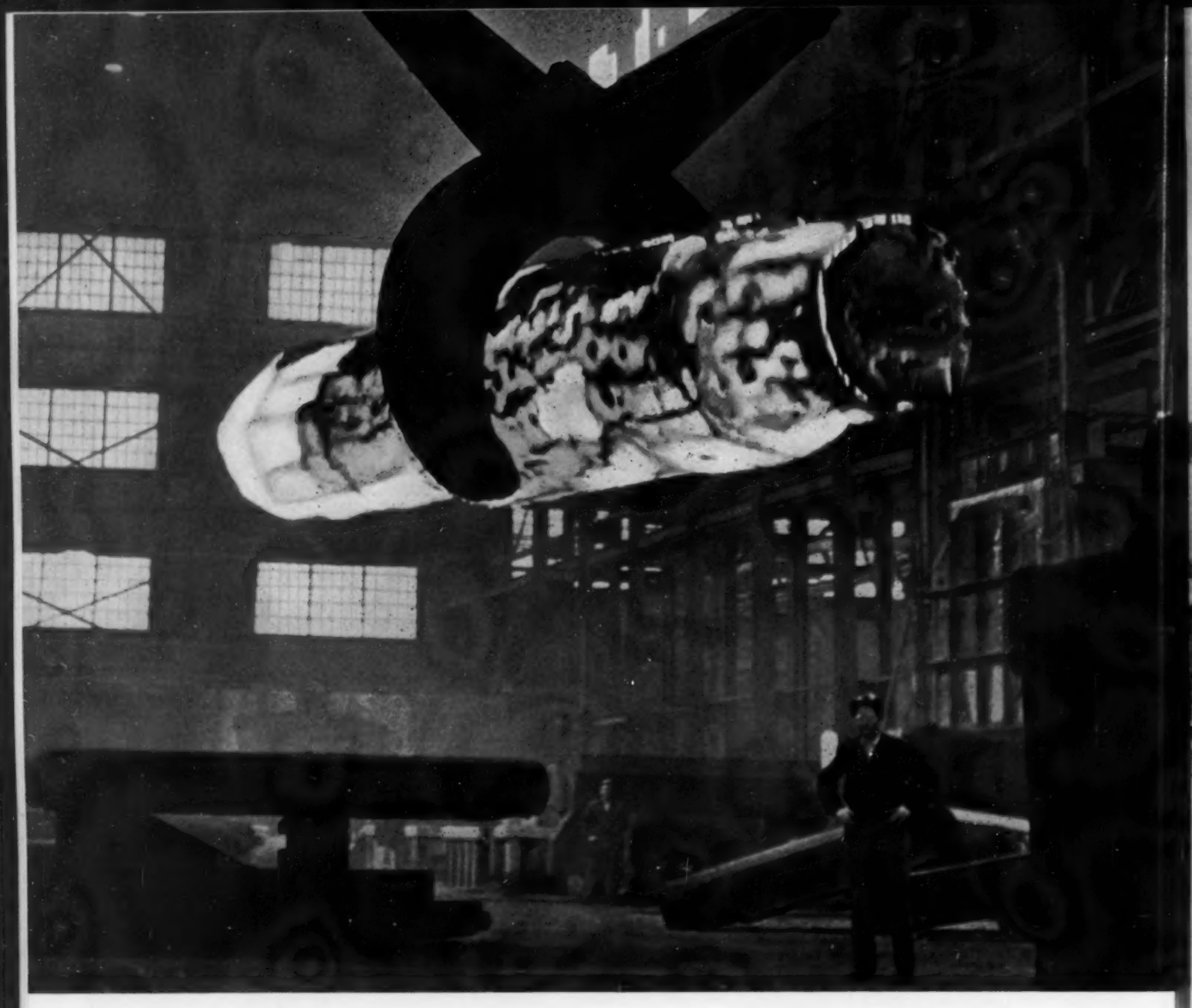
Add up all these advantages and you see why the Wheelabrator method is the most efficient mill roll etching process yet devised.

A Wheelabrator cabinet can be tailored to fit your specific needs. Send today for more complete information.

WHEELABRATOR
CORPORATION
(Formerly American Wheelabrator & Equipment Corp.)

396 S. Byrkit Street Mishawaka, Indiana

First in Mechanical Descaling



Another Big One on the Way

This glowing mass of steel winging through the air is a large forged roll in the making. As you see it here, it has been blocked and reheated, and is now en route to the second forging operation. When the Bethlehem shops have finished with it, the roll will have a maximum diameter of 36 in. and a length of 10 ft. It will weigh 21 tons after finish-machining and grinding. The customer plans to use it for hot-rolling aluminum.

Rolls like this require the most painstaking care in every detail of manufacture. At Bethlehem they get it. Steel-making, forging, heat-treating and machining are all in expert hands, and the strictest metallurgical controls are enforced throughout. When a Bethlehem roll emerges from the shops, it meets all specifications on size, finish, hardness. It's ready for action.

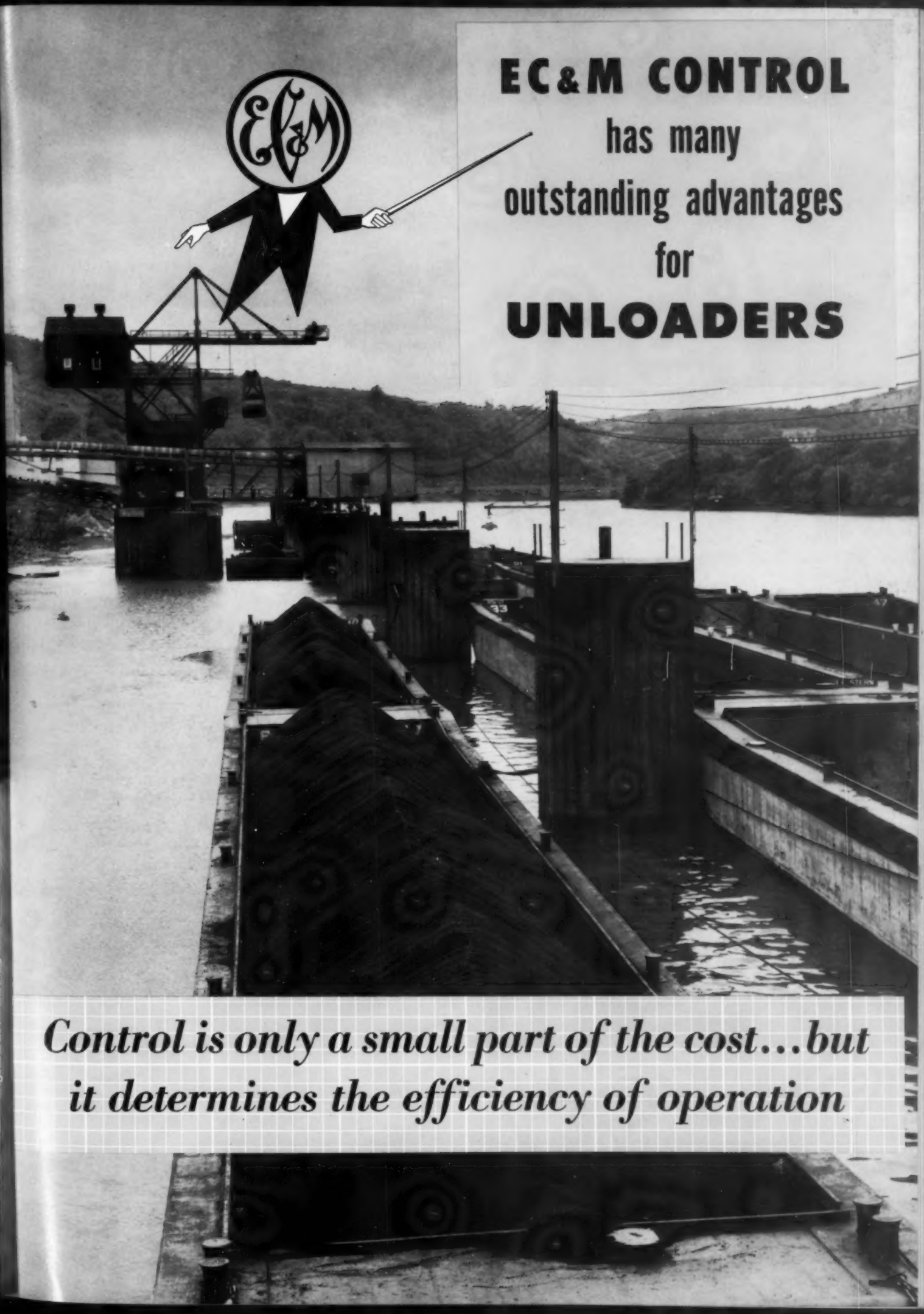
Whatever your needs in rolls, we can meet them to your entire satisfaction. Call us if your operations involve cold-rolling ferrous sheets and strip . . . running-down and finishing steps on copper and brass sheets . . . hot- and cold-rolling aluminum sheets . . . cold-rolling aluminum foil.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL



EC&M CONTROL
has many outstanding advantages for
UNLOADERS

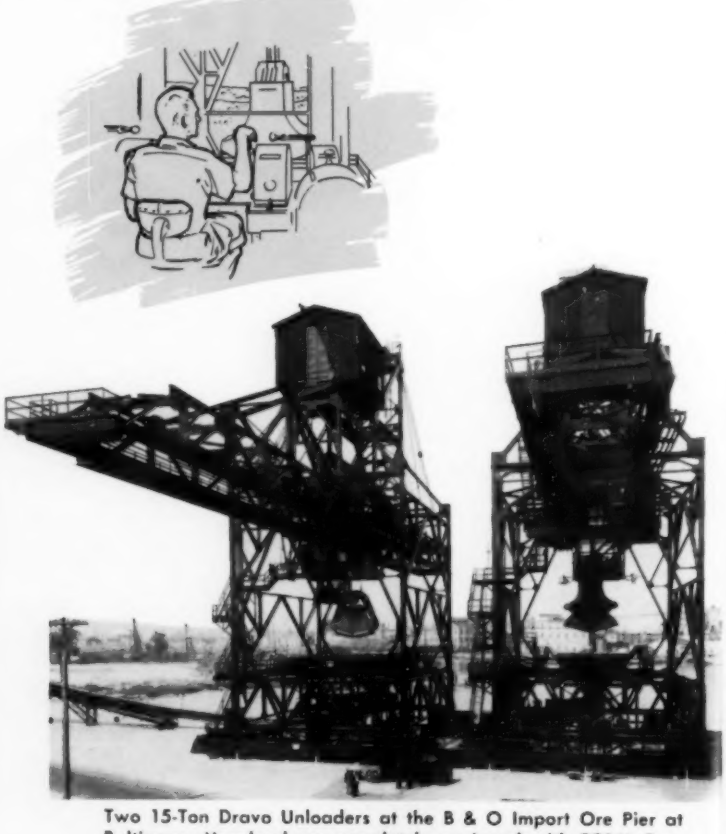
Control is only a small part of the cost...but it determines the efficiency of operation

EC&M CONTROLLERS . . .

Coal is handled from barge to power plant at an eastern electric generating plant at the rate of 400 tons per hour by this Clyde Unloader equipped with EC&M Control. **Photos — courtesy of Clyde Iron Works, Inc.**

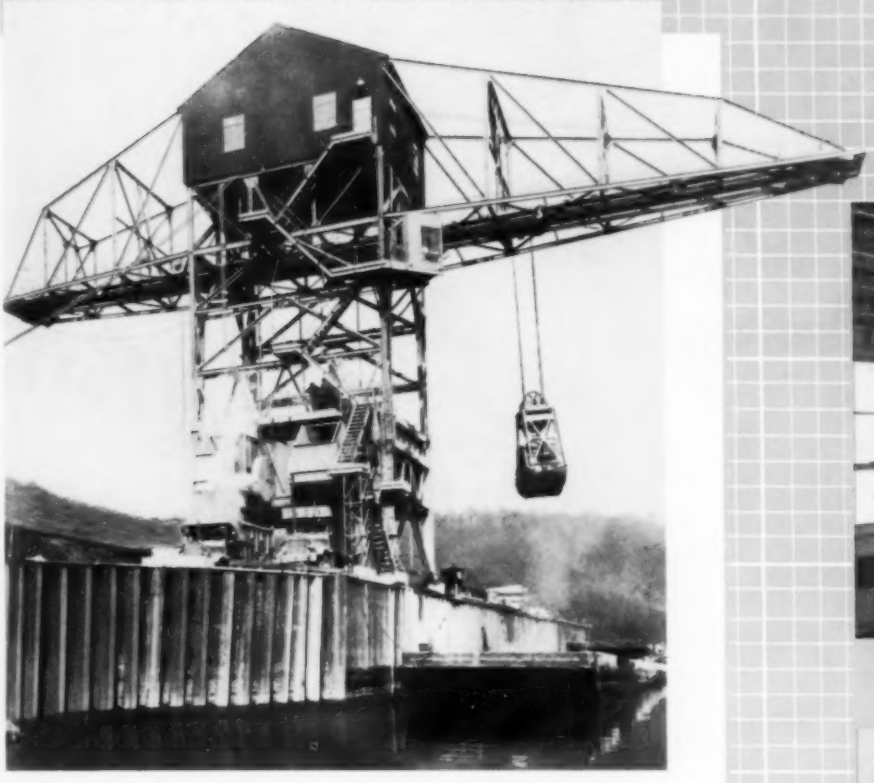
Barges of coal (900 tons per barge) as shown on the preceding page, are unloaded by this 7-Ton Wellman Unloading Tower under EC&M Control at a western Pennsylvania generating plant. **Photos — courtesy of West Penn Power Co.**

On the Ohio River, this McKiernan-Terry Unloading Tower equipped with EC&M Control lifts coal from river barges at the rate of 1200-Tons per hour to supply this generating plant.



Two 15-Ton Dravo Unloaders at the B & O Import Ore Pier at Baltimore, Maryland are completely equipped with EC&M Control. This pier established an eastern seaport record for unloading ocean vessels.

operating from standard voltages . . .
are low in cost, safe, simple and easy to operate



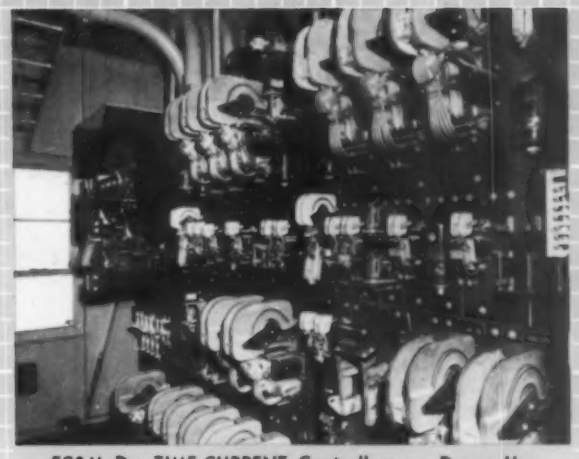
500-ton-per-hour Barge Unloader, designed, fabricated and erected by Heyl & Patterson for the Duquesne Slag Company, Pittsburgh, Pa., and equipped with EC&M Control has been giving excellent results for many years.

Ton by ton . . . EC&M Control helps move bulk materials with an increased output and lower cost that appeal to management. Operators appreciate the smoothness of performance and quick manipulation.

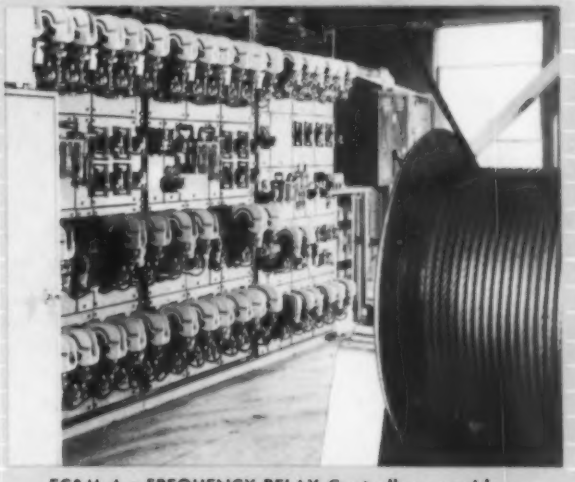
Time-saving advantages of this Control are numerous. Some of these are: facility for paying out cable to dig into the pile, taking the swing out of a loaded bucket at the point of discharge, and keeping the bucket open when lowering for another load.

On river unloading stations, at lake and ocean ports, EC&M Control has earned a reputation for fast lifts . . . safe lifts. To EC&M, each material handling machine is thoroughly investigated . . . the mechanical as well as electrical details, the duty cycle and all important data are considered. From *these facts,* EC&M *accurately engineers* the control for the individual job . . . this results in the greatest service at lowest maintenance. EC&M Control is well-known for reduced manpower and lower renewal part expense. Look at the proof of acceptance of EC&M Control for the wide range of applications shown here.

It pays to "SPECIFY EC&M CONTROL"



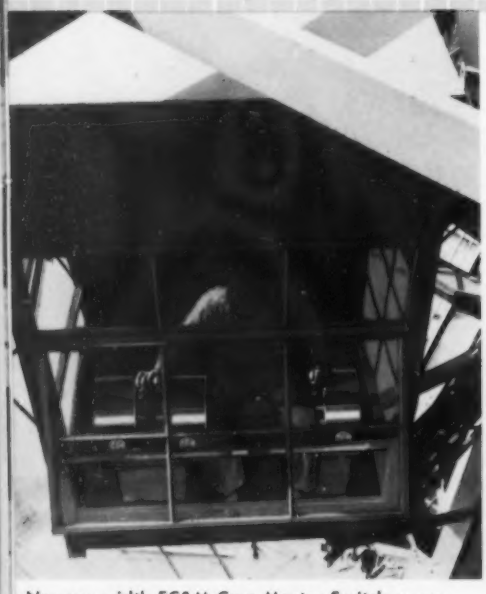
EC&M D-c TIME-CURRENT Controllers on Dravo Unloaders. All power is brought into the operator's cab on this installation for maximum safety.



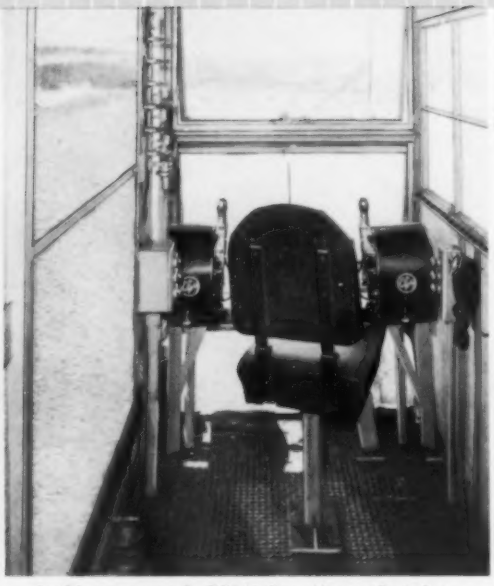
EC&M A-c FREQUENCY-RELAY Controllers provide accurate switching of Closing and Holding Line circuits to give maximum safe torque output of the a-c motor.

This view shows EC&M Type WB Brake, Frequency Relay Controllers in Cabinets with TAB-WELD Plate Resistors mounted overhead.

Quick Response coordinated with *Safe Operation*



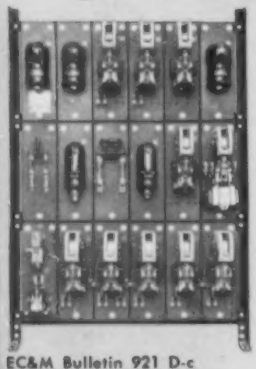
Narrow width EC&M Cam Master Switches are closely grouped for operator's convenience in this cab.



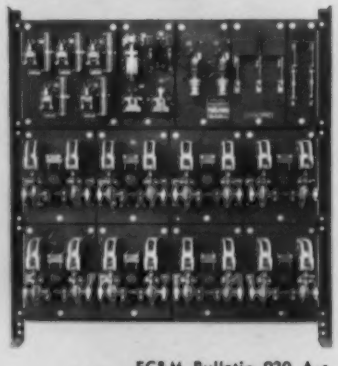
In this narrow cab, EC&M Cam Master Switches require minimum space. This short throw of operating handles contributes to the ease of operation.

Here, the operator controls the Trolley movement through a Foot Master Switch. Hand-operated EC&M Cam Master Switches are used to control the bucket operation.

Control Engineered for the Job gives smoother performance



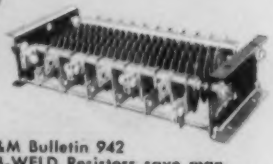
EC&M Bulletin 921 D-c Crane-hoist Controller uses the Wright Circuit for safety, simplicity.



EC&M Bulletin 930 A-c Contra-torque Hoist Controller with Frequency Relays for acceleration, plugging and speed limiting functions.

Bulletin 1190 C&M Cam Master witches are narrow in idth and have a short row from full-on to ll-off positions.

EC&M Bulletin 1000 WB Brakes give fast release . . . quick set. Are supplied for rectifier-operation on A-c motors.



EC&M Bulletin 942 TAB-WELD Resistors save manpower. No periodic clamping-nut tightening . . . no burning at grid eyes or at top-plates.

Here's where EC&M Control excels

FAST GETAWAY EC&M uses load-responsive acceleration relays (Time Current on d-c, Frequency Relay on a-c) to provide maximum, safe torque values for efficient unloader operation. These exclusive EC&M Relays provide the fastest, safest acceleration which results in rapid bucket handling . . . fast trolley movement . . . overall reduced time between trips.

WIDE SPEED SELECTION The operator always has at his command a choice of speed-points. And the better speed-range on each point provides greater flexibility for normal operation and during clean-up.

SMOOTHER STOPPING When checking motor lowering speeds, the Resistor values of EC&M Control are *accurately designed* to give quick, safe, smooth stopping of light loads, full loads or the empty bucket. EC&M Acceleration and Plugging Relays automatically govern the rate of acceleration, stopping and reversal of the trolley motion for top performance.

SPEED-LIMITING *Safety* on all Speeds. EC&M High-speed Contactors respond instantly to the Operator's manipulation of the Master Switch; motor connections are switched quickly to conform with the well-known characteristics of EC&M Circuits, which maintain safe lowering and operating conditions at all times.

When buying UNLOADERS, specify EC&M Control

SQUARE D COMPANY

EC & M DIVISION • CLEVELAND 28, OHIO

6826

LITHOGRAPHED IN U.S.A.

ONE OF A SERIES . . .

What makes a cylindrical roller bearing good?

The RIGHT ROLLER DESIGN and QUALITY CONTROL

The design and quality of the *rollers* play a large part in the performance of a cylindrical roller bearing. At right are some of the vital factors which must be considered.

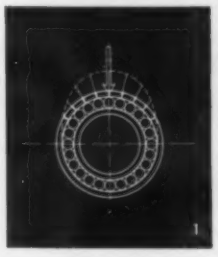
All these factors are scrupulously controlled by the most modern precision equipment to insure maximum performance and life for every HYATT Roller Bearing. You'll find more details in HYATT General Catalog No. 150, or your nearby HYATT Sales Engineer will gladly help you choose the type best suited to your requirements. Remember, HYATT is America's *first* and *foremost* maker of cylindrical roller bearings. Hyatt Bearings Division of General Motors, Harrison, New Jersey.

GM GENERAL MOTORS

HYATT ROLLER BEARINGS

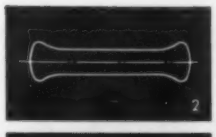
1. DISTRIBUTION OF LOAD WITHIN THE BEARING

Rollers are subjected to load only while in the "load zone," with maximum load while on the line of action of the bearing load, as shown in diagram 1. The theoretically perfect "load zone" extends from −90° to +90° from the line of action, but this is neither practical nor necessarily desirable. Under normal loadings, the actual "load zone" may range from 90° to 120°, depending on load and mounted internal clearance. This distributes the load so the load on the heaviest-loaded roller is approximately 5/N times the bearing load, where N is number of rollers.



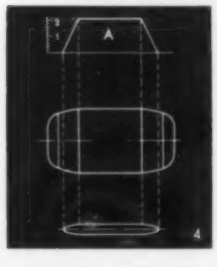
2. DISTRIBUTION OF LOAD WITHIN ROLLER'S AREA OF CONTACT

A cylinder deflects locally in the region of engagement when loaded between flat plates. The plate also deflects, so the original line of engagement is broadened into a "dog-boned" area under load, as shown in diagram 2. Moreover, deflected cylinders must gather in metal at their ends in *two planes, and this end-loading effect can seriously reduce the life of a cylindrical roller bearing.* All HYATT rollers have generous corner radii or blended chamfers to reduce end effect; and all HYATT Hy-Load rollers also have crowning to allow the contact area to "fade out" evenly (diagram 3).



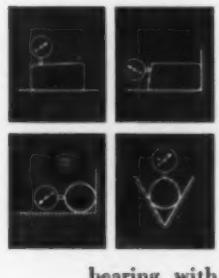
3. DISTRIBUTION OF LOAD ACROSS ROLLER

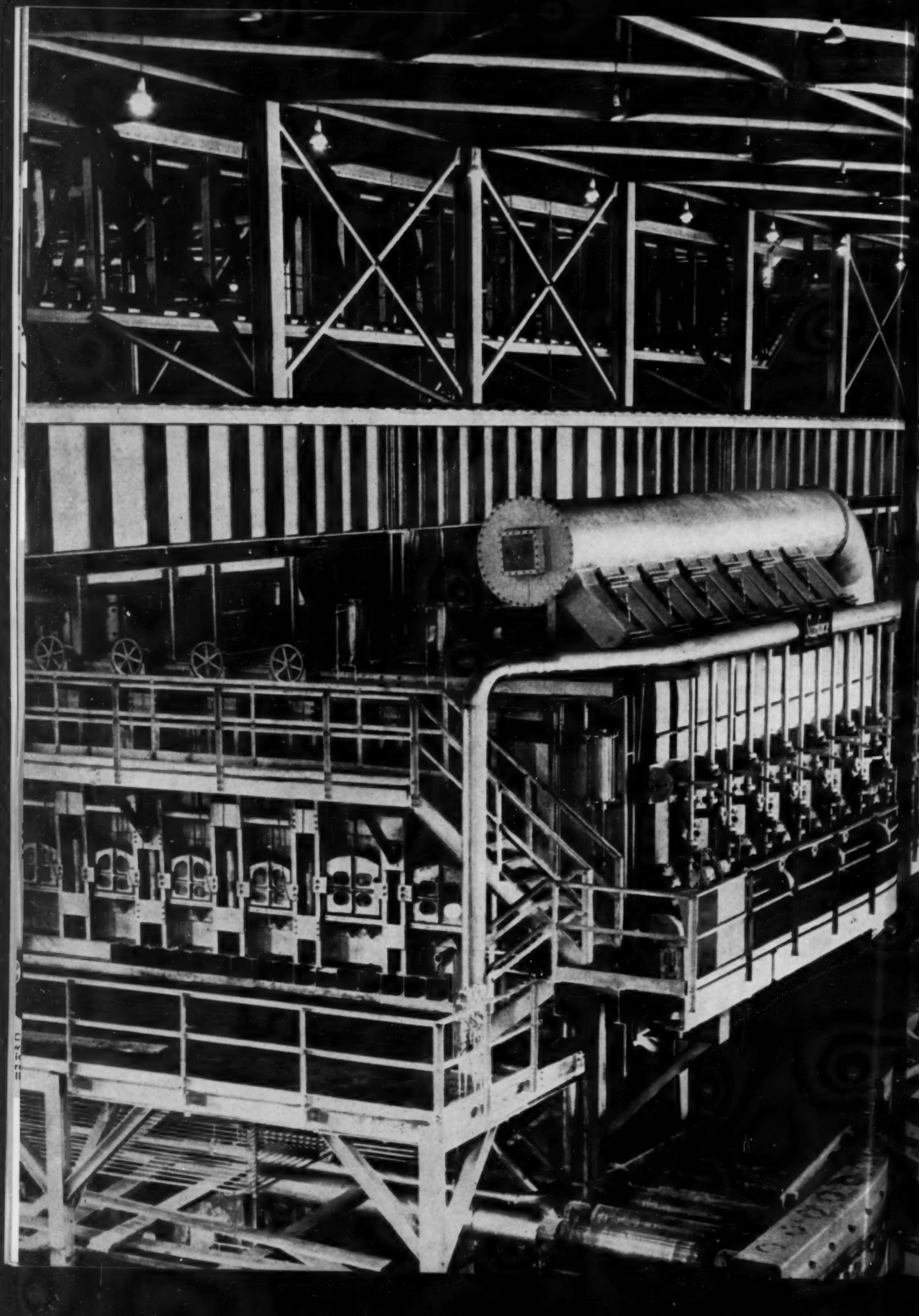
The unit load on any roller is uniformly distributed axially except at the crowned ends where it drops off to zero as shown in diagram 4. The summation of unit loads represented by area A is the total roller load. This same load under misalignment results in an area equal to area A; but maximum unit load is considerably greater and the bearing will have a shorter life than a properly aligned one. When the same total load is applied to an *uncrowned* roller, an even higher unit load results. This demonstrates the value of crowning when misalignment occurs.

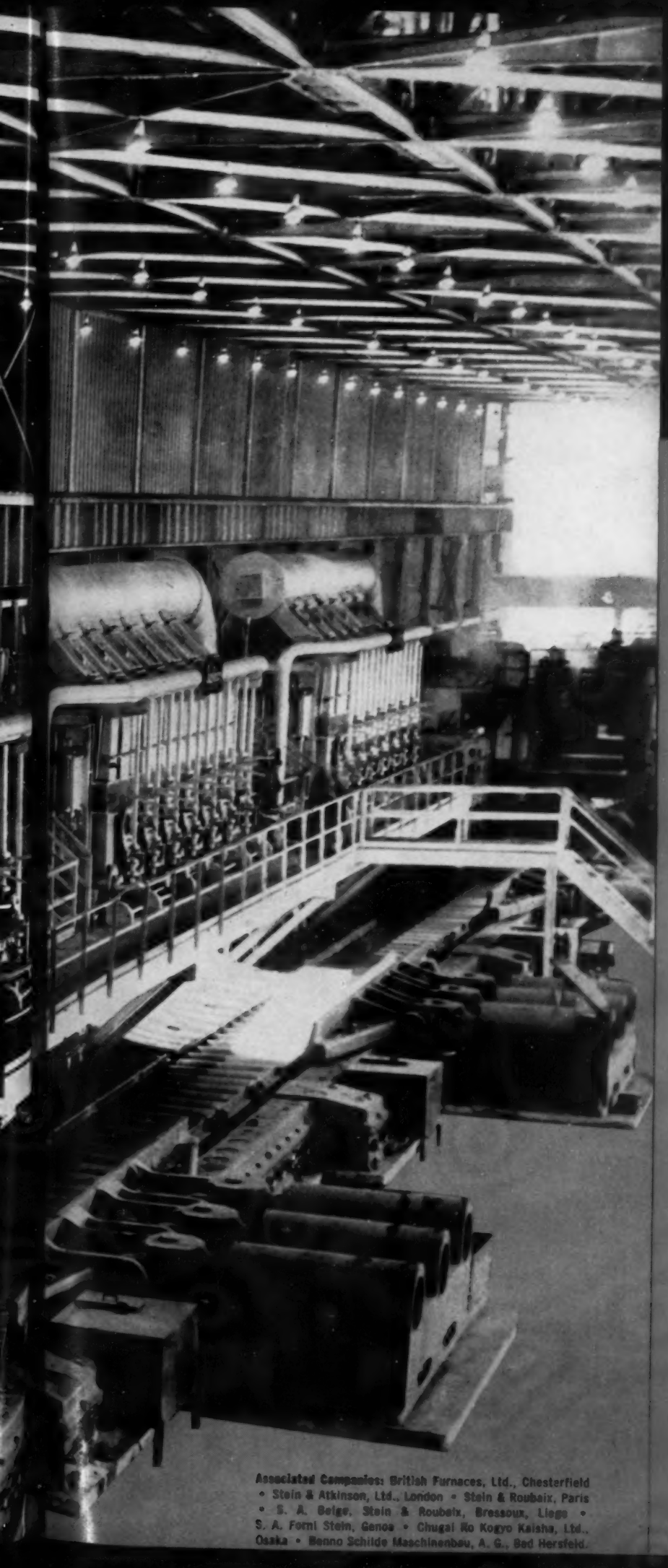


4. EFFECT OF ROLLER QUALITY ON BEARING PERFORMANCE

Lack of roller quality control has a very adverse effect on performance: 1. A roller with excessive *taper* tends to uneven load distribution and abnormal temperature rise. 2. A roller with excessive *end square* tends to noisy bearing performance. 3. A roller with excessive *two-point out-of-round* tends to poor segregation and poor bearing life. 4. A roller with excessive *three-point out-of-round* tends to noisy bearing operation. 5. A roller with *poor finish* tends to wear on all operating surfaces and noisy operation. 6. A bearing with excessive *roller-to-roller diameter variation* tends to poor bearing life. 7. A bearing with excessive *roller-to-roller length variation* tends to poor thrust capacity, abnormal temperature rise.







200 TONS AN HOUR CONTINUOUSLY

200 tons of steel slabs are heated to rolling temperature every hour, continuously, in each of these Surface monsters—world's largest slab furnaces.

No other furnace today can list all of these features:

1 Cantilever skid supports* permitting unobstructed combustion space for underfiring.

2 Furnace lines and burner design which provide high heat input from the moment the slab enters the furnace.

3 Built-in control* to prevent intermingling of gases from upper and bottom zones, providing better control of heat application, and preventing overheated slab end.

4 Anticipatory control which reduces temperature head when rate of slab discharge decreases.

5 Air preheat up to 1100°F.

6 Television signal to pusher pulpit, informing operator of the exact position of the leading slab.

About the only conventional feature in these giants is the fact that the slabs are pushed in one end and out the other.

This is another demonstration that, at Surface, unconventional thinking and conventional experience are a productive team for the steel industry. Surface Combustion Corporation, Toledo 1, Ohio.

*patents pending

Surface
STEEL MILL EQUIPMENT

Associated Companies: British Furnaces, Ltd., Chesterfield • Stein & Atkinson, Ltd., London • Stein & Roubaix, Paris • S. A. Belge, Stein & Roubaix, Bressoux, Liege • S. A. Forni Stein, Genoa • Chugai Ro Kogyo Kaisha, Ltd., Osaka • Benno Schilde Maschinenbau, A. G., Bad Hersfeld.

for lower maintenance

it's ohio magnets

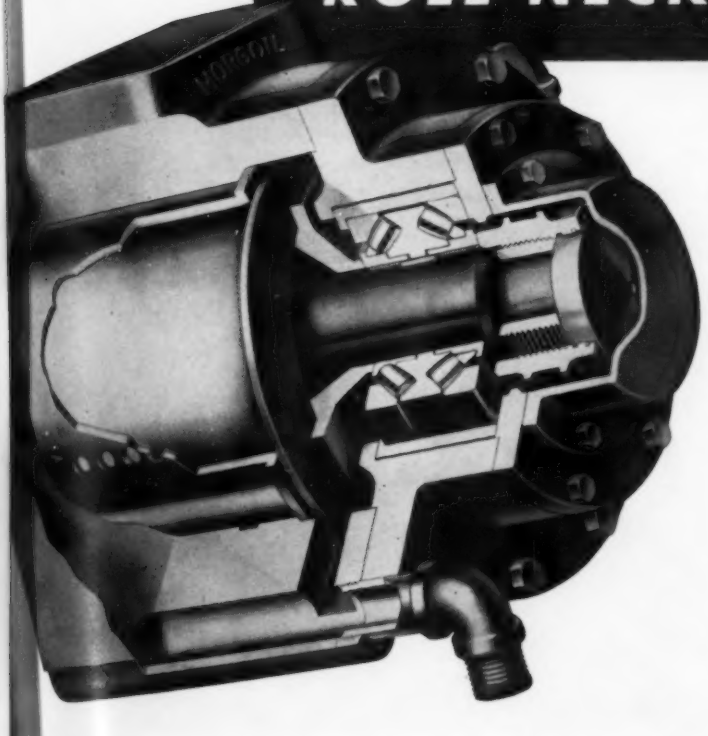
Ohio Magnets cost less to maintain because they're built with an extra margin of safety. So for extra magnet life, extra magnet value—always specify Ohio Magnets and Ohio Magnet Controllers. There's a type and size for every lifting job. Send for free copy of Bulletin 112, or consult the Yellow Pages for Ohio offices in principal cities. AA-1478

THE OHIO ELECTRIC MFG. CO.
5400 DUNHAM ROAD • MAPLE HEIGHTS
CLEVELAND, OHIO

Ohio Also Makes Separation Magnets • Nail Making Machines • Fractional Horsepower, Shell and Torque Motors

Morgan Quality in Action

MORGOIL
ROLL NECK BEARINGS



These 26″-90 MORGOIL Bearings are operating in a 10½″ & 30″ x 30″ single stand four high reversing cold mill at Lombarde Falck in Milan, Italy. Hot mills or cold mills, ferrous or nonferrous, at home or abroad, MORGOILS give the best roll neck bearing performance at the lowest cost.

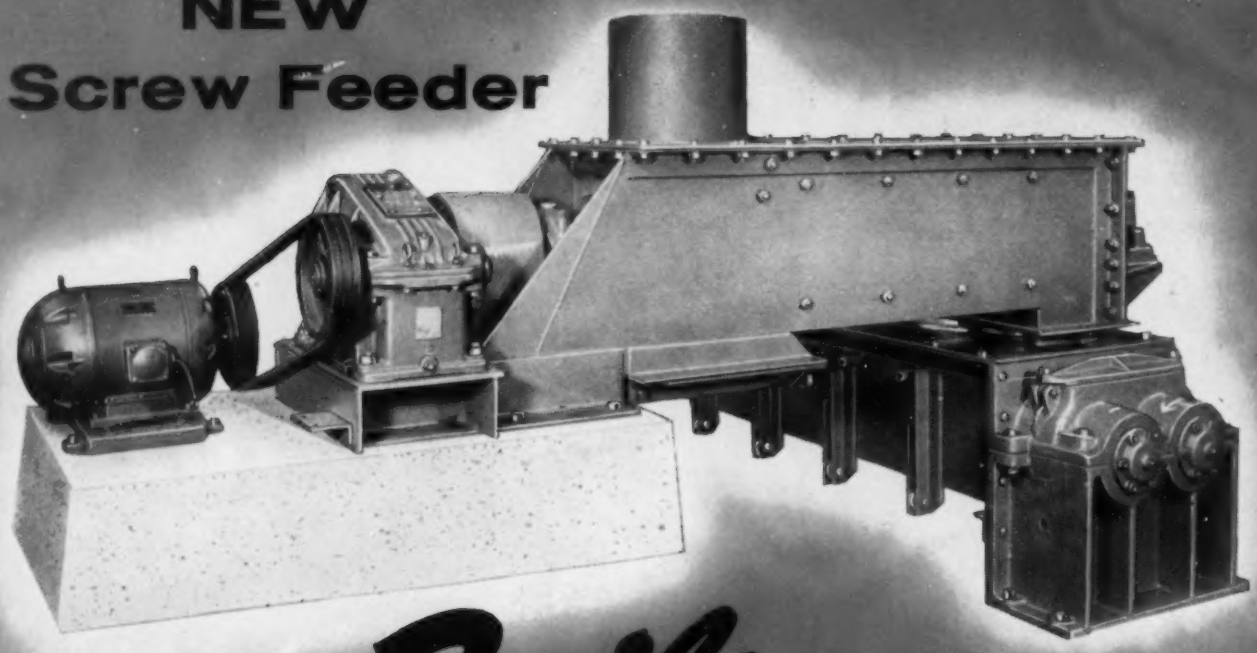
MORGAN CONSTRUCTION CO.
WORCESTER, MASSACHUSETTS
ROLLING MILLS MORGOIL BEARINGS GAS PRODUCERS
WIRE MILLS EJECTORS REGENERATIVE FURNACE CONTROL

MB-50

MORGAN WORCESTER MORGAN WORCESTER MORGAN WORCESTER MORGAN WORCESTER MORGAN WORCESTER MORGAN WORCESTER MORGAN WORCESTER MORGAN WORCESTER

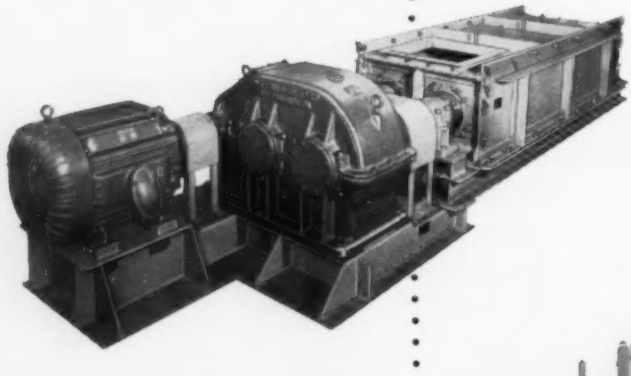
MORGAN WORCESTER MORGAN WORCESTER MORGAN WORCESTER MORGAN WORCESTER MORGAN WORCESTER MORGAN WORCESTER MORGAN WORCESTER MORGAN WORCESTER

NEW Screw Feeder



MAKES *Bailey* PUG MILLS

EVEN MORE EFFECTIVE IN SINTERING PLANT AND BLAST FURNACE DUST CATCHER SERVICE



This Bailey Double Shaft Pug Mill is equipped with a double helical gear reduction unit. Types of Bailey Pug Mills available include single and double shaft types, with direct or rope drives.

The new Bailey Screw Feeder is effective for flow regulation and conveying of flue dust, ore fines and various other materials. An outstanding feature is that it maintains uniform flow, even when irregular feeding may be caused by "hanging" of material in dust catcher or a sudden furnace "slip." The feeder speeds the sintering process and assures substantial savings through reduced handling costs.

BAILEY PUG MILLS were developed for low-cost processing of greater tonnages of more uniform sintered products. They are built for continuous service, in capacities from 100 to 400 tons per hour.

Write for Bulletins

WILLIAM M. *Bailey* COMPANY

ENGINEERS

LEADERSHIP THROUGH QUALITY

1221 BANKSVILLE ROAD PITTSBURGH 16, PA

To help you maintain uninterrupted production schedules . . .

SPECIFY NATIONAL ROLLS

All grades and sizes of iron, alloy iron, steel and alloy steel rolls for metal rolling and forming that meet your requirements for precision and long service life.

- PLAIN CHILLED IRON ROLLS
- SAND IRON ROLLS
- MOLYBDENUM CHILLED IRON ROLLS
- RAIL FINISHING IRON ROLLS
- GRAIN IRON ROLLS
- N-I IRON ROLLS
- NICKEL IRON ROLLS
- NN NICKEL IRON ROLLS
- CARBON STEEL ROLLS
- M-C STEEL ROLLS
- MONICRO STEEL ROLLS

THE NATIONAL ROLL & FOUNDRY CO.

A Wholly-owned Subsidiary of General Steel Castings Corporation

Avonmore (Westmoreland County) Pennsylvania

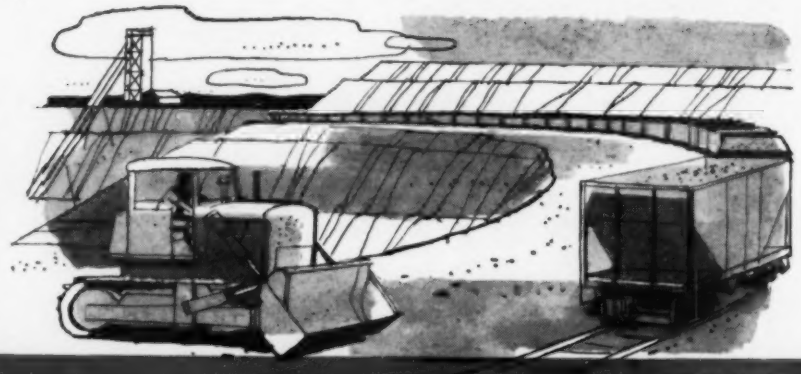
Specialists in Iron, Alloy Iron and Steel Rolls, Carbon, Alloy and Manganese Steel Castings

From Mine to Mill

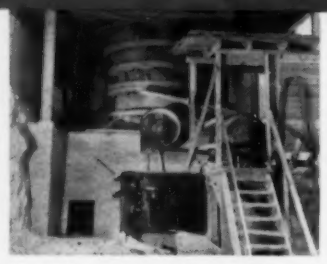
Allis-Chalmers Equipment serves in every part of the Steel Industry... Dependably, Economically

For more than three quarters of a century, Allis-Chalmers has served the steel industry — supplying the equipment needed to produce top quality steel... the manufacturing "know-how" to meet heavy-duty operating conditions... the pioneering spirit to keep up with the changing requirements of the industry. Allis-Chalmers machines are employed, not just in one phase, but all through the steel-making process. For complete information on how Allis-Chalmers can help solve your machinery problems, consult your Allis-Chalmers district office or write Allis-Chalmers, Milwaukee 1, Wis.

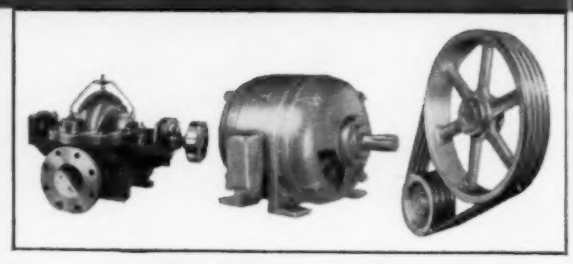
Regulex and *Texrope* are Allis-Chalmers trademarks.



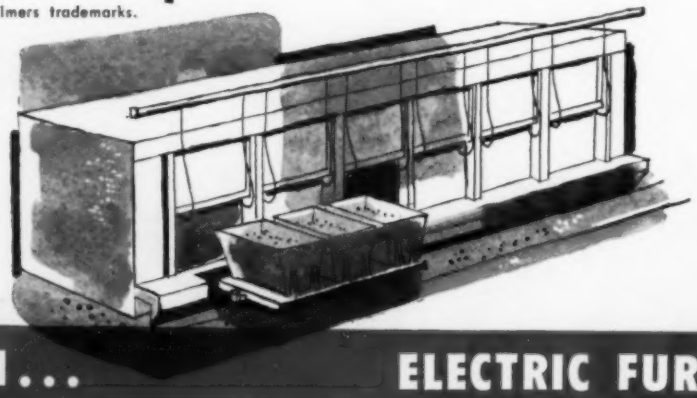
MINES...

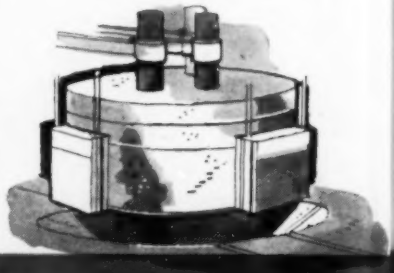


Crushers, grinding mills, vibrating screens engineered and manufactured by Allis-Chalmers crush the ore-bearing rock, grind it to specified size, size and wash metallic ores, stone and coal.

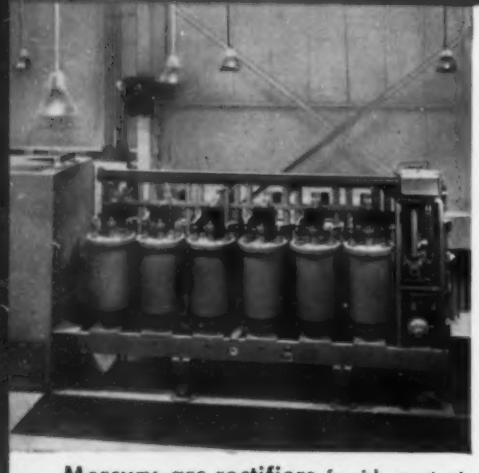


Allis-Chalmers pumps, motors, *Texrope* drives are in wide use throughout the metal industry because of their long life characteristics, low maintenance requirements and great versatility.

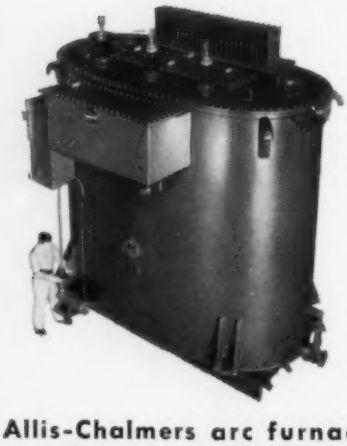




OPEN HEARTH... ELECTRIC FURNACE...

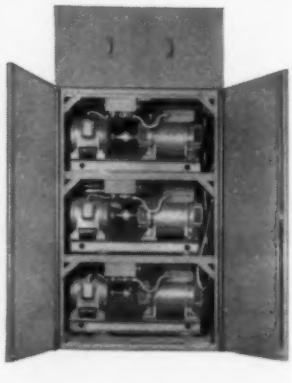


Mercury-arc rectifiers furnish constant voltage dc power for material handling in open hearth and other mill operations and for mine haulage. Variable voltage units are supplied for supporting main roll drives.



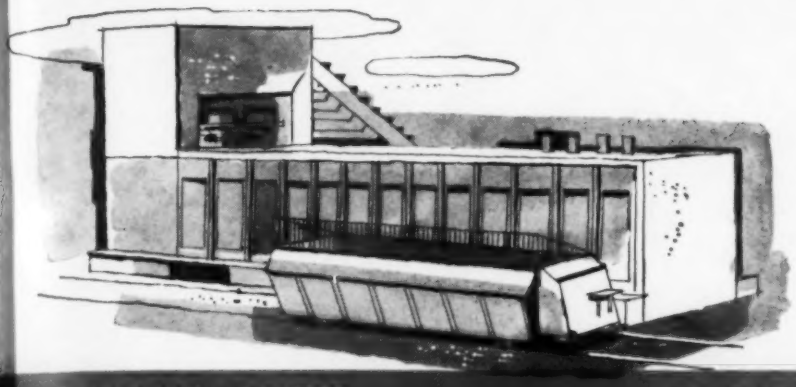
Allis-Chalmers arc furnace transformers are of well-balanced design and extra heavy duty construction — proven in 25-30 years of repeated daily short-circuits in electric furnace operation.

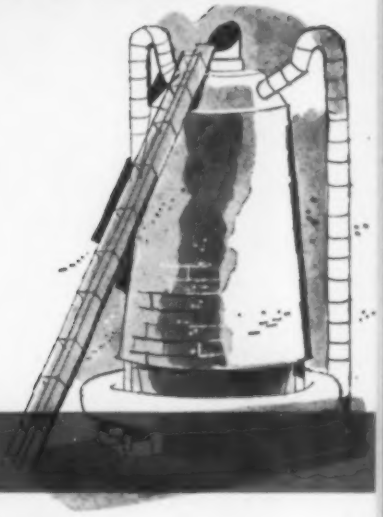
***Regulex* control** balances arc current with arc voltage, almost instantly — maintains desired arc condition automatically.



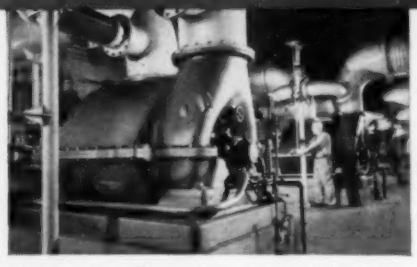
ALLIS-

. . It's Allis-Chalmers



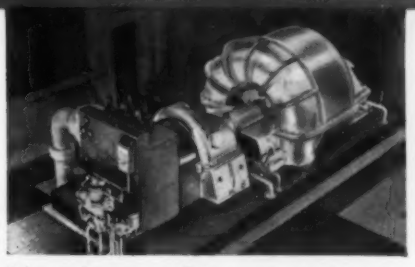


COKE OVEN...



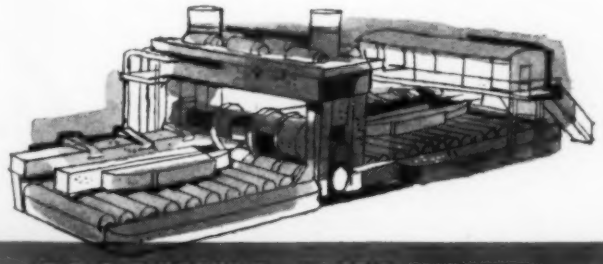
Booster, exhauster or combination service requirements are met by Allis-Chalmers blowers. Photo shows four 23,000-cfm, 5100-rpm, 3.5-psig centrifugal exhausting blowers in a western steel mill.

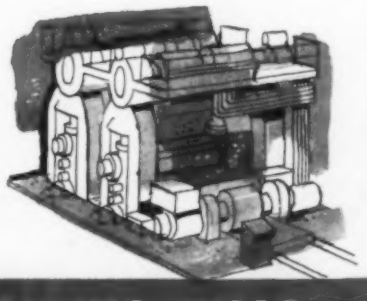
BLAST FURNACE...



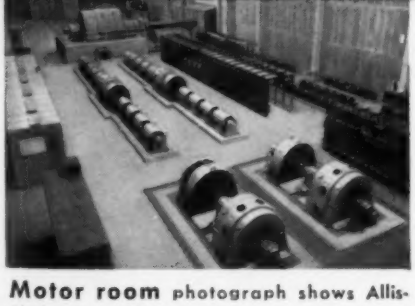
Blast furnace blowers furnished by Allis-Chalmers meet blast furnace requirements. The 75,000-cfm, 30-psig centrifugal blower shown here has been in service since 1942. It is driven by an 8500-hp steam turbine.

Allis-Chalmers axial blowers are designed for high efficiency blast furnace duty. They are smaller, easier to install — save $50,000 or more in steam per year. A-C also builds constant efficiency rotary compressors.



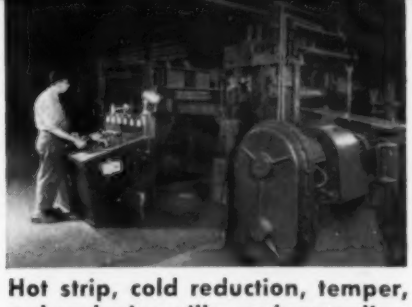


BLOOMING MILL...



Motor room photograph shows Allis-Chalmers switchgear, control, constant and variable voltage motor-generator sets, *Regulex* m-g sets, liquid rheostat, and twin-drive motors in use in a midwestern steel plant.

FINISHING MILLS...



Hot strip, cold reduction, temper, rod and wire mills, and annealing and pickling lines employ Allis-Chalmers control, power equipment and drive motors for dependable operation.

Other Equipment

Besides the power utilization and conversion equipment illustrated, Allis-Chalmers also supplies power generation and distribution requirements from mine to mill.

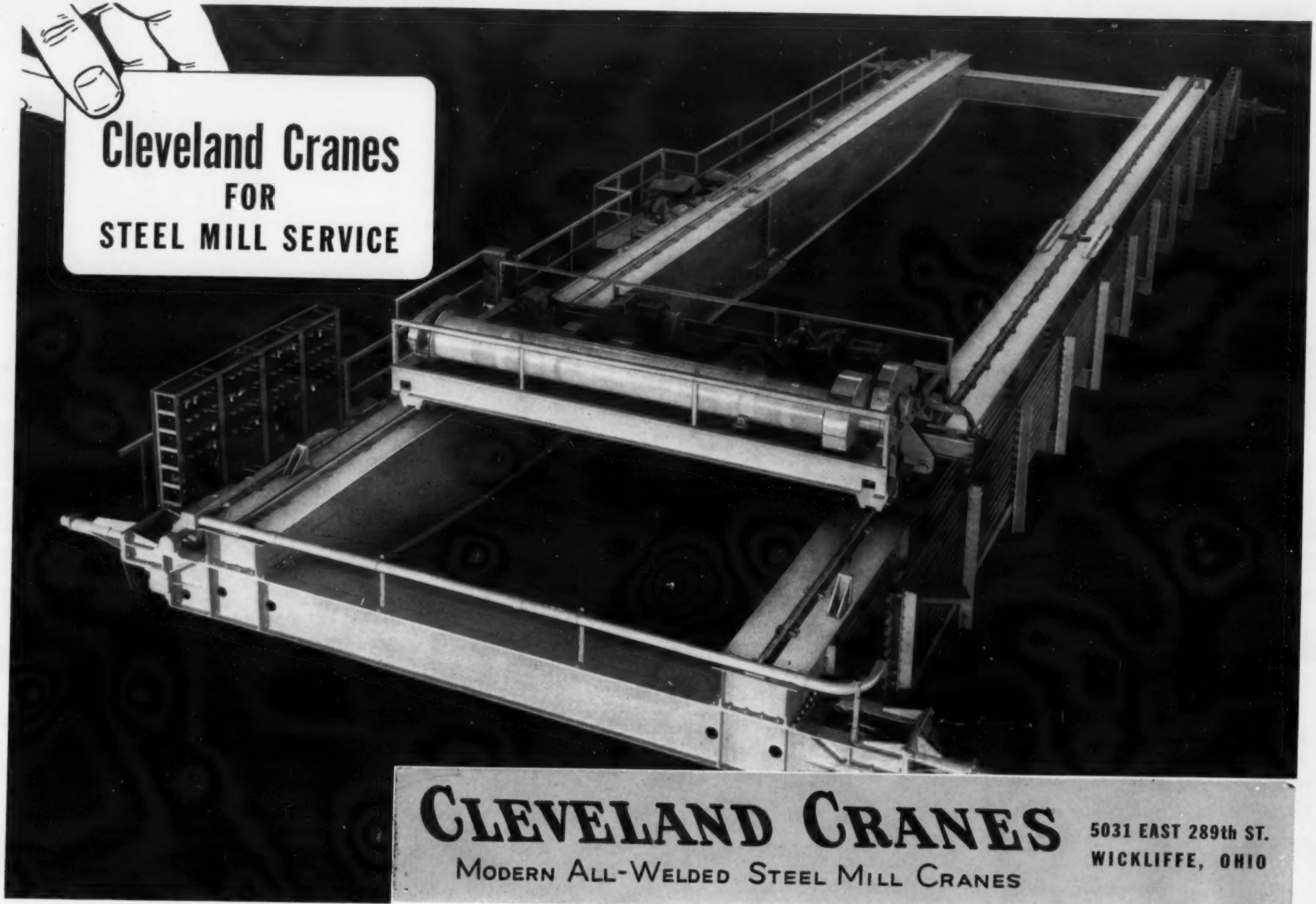
For power generation, A-C builds steam turbine-generator units, surface condensers, water conditioning equipment, pumps, motors, and control. Also hydraulic turbines, generators, governors, and valves. For power distribution, A-C furnishes transformers, voltage regulators, circuit breakers, switchgear, and substations.

Throughout this wide range of products, you can depend on Allis-Chalmers for equipment engineered to meet your exact needs.

CHALMERS

A-C ALLIS-CHALMERS

A-4907


Cleveland Cranes
FOR
STEEL MILL SERVICE
CLEVELAND CRANES
MODERN ALL-WELDED STEEL MILL CRANES
5031 EAST 289th ST.
WICKLIFFE, OHIO

Crops and Shorts

AS this is written, the steel strike is entering its second week. Negotiations which seemed to get away to such an auspicious start ran into an unfortunate impasse. Both labor and management seemed loath to make any propositions that differed perceptably from their original plans. And so negotiations bogged down in a morass of name-calling and catch phrases designed for the public eye.

Actually, the contract offered by the steel companies is a pretty good one, but perhaps they should have started lower and bargained up to it. Any ultimatum is infuriating.

We believe that a three-year contract would be accepted by the union, and it wouldn't have to carry much higher raises and benefits than have already been offered—particularly if most of the increase is in the form of direct pay, in which most of the workers are primarily interested.

▲

INCIDENTALLY, the original offer made by the steel companies included a new paid holiday, which the companies suggested should be the day before Christmas. Maybe they should consider the holiday established by a company in Vermont, which is the opening day of the trout season.

▲

JUST to prove the old saw about making strange bed-fellows, UAW's Walter Reuther and General Motors' Harlow Curtice have advocated government aid for the "depressed" automobile industry.

Shades of 1932! If anyone at that time had dreamed of a level of auto business such as now exists, the men in the white coats would have been after him. As one chap recently remarked: "If we hadn't expanded so much, we'd have thought we were having a hell of a good year."

▲

ANOTHER example of strange bed-fellows is to be found in United States Steel Supply's handling aluminum in the Chicago area.

▲

THIS year marks the 50th anniversary of the first electric arc furnace operation in the United States.

Also, Gary, Ind., and the United States Steel plants there celebrated the fiftieth anniversary of groundbreaking with hirsute adornments and a series of successful open houses.

ANOTHER 50th anniversary is that of General Electric's suggestion box plan. This system receives a suggestion every six minutes and accepts one every 18 minutes. The maximum award thus far paid for a suggestion is $5000.

▲

OUR Detroit spy reports that the next new accessory to be put on automobiles is a push button which causes an indicator to show the date of the next payment.

▲

FIGURES released by the American Iron & Steel Institute show that blast furnaces of the United States are gradually operating more and more efficiently. In 1955 these furnaces used 127,752,610 net tons of iron ore, 3,752,380 net tons of scrap, 11,457,129 tons of mill cinder, etc., 68,506,721 tons of coke and 30,244,707 tons of fluxes to produce 77,789,684 tons of iron. Compared with 1953 figures, coke consumption is down 1.5 per cent and fluxes down 5.2 per cent, although iron output is 2.5 per cent higher.

In 1955, open hearth furnaces consumed 1,584,752,319 gal of fuel oil, 106,049,000,000 cu ft of coke oven gas, 55,354,000,000 cu ft of natural gas and 422,780,274 gal of tar and pitch while producing 105,359,417 net tons of ingots. These figures represent increased use of natural gas, tar and pitch, and lower consumption of fuel oil and coke oven gas.

▲

EXPENDITURES of all business for plants and equipment is increasing and is expected to hit an annual rate of $36,700,000,000 in the third quarter.

▲

A disillusioned friend has simplified golf into a game in which a ball 1½ in. in diameter is placed on another ball 8000 miles in diameter, the object being to hit the small ball but not the large one.

▲

ADDRESSING the Canadian Manufacturers Association, Admiral Ben Moreell, chairman of Jones & Laughlin Steel Corp., said: "Socialism has come to be the common faith of most men in mid-twentieth century, while socialism as an autonomous movement has become weaker because the Republican and Democratic parties have stolen its platform, plank by plank."

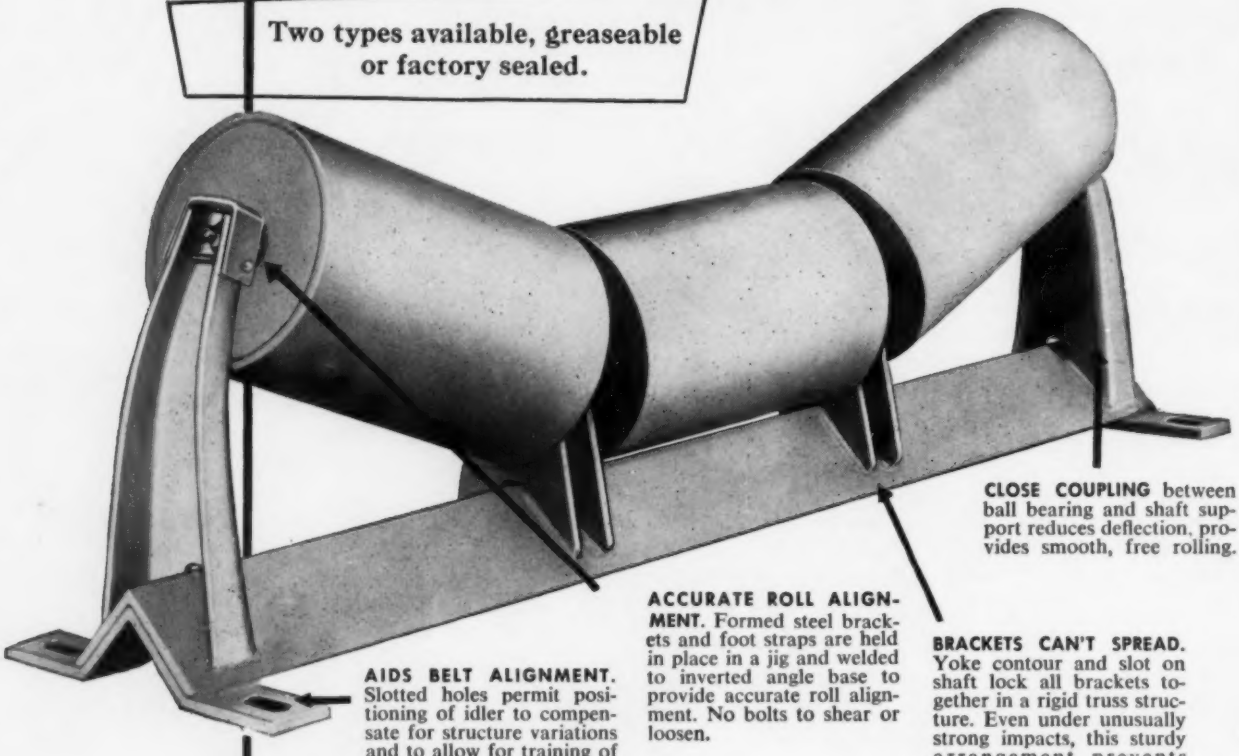
▲

C. G. PARKER, president of the National Association of Manufacturers, told that group: "Nobody begrudges American workmen the enjoyment of high wages justified by high productivity. But the union bosses are engaged in a contest to get the most they can regardless of productivity. And wage increases not justified by increased productivity are a detriment to their own union members, who can be most harmed by inflation."

"Consciously or unconsciously, the chief objective of today's labor leadership is not only to extend but to perpetuate its economic and political power. And if they can achieve political dominance they will be able to dictate legislatively what they could not obtain across the bargaining table or justify economically."

NEW! LINK-BELT Series 50 idler

Two types available, greaseable or factory sealed.

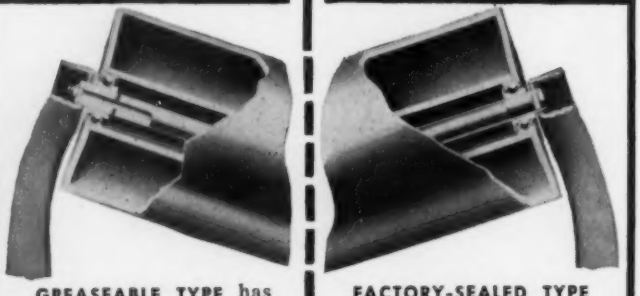


CLOSE COUPLING between ball bearing and shaft support reduces deflection, provides smooth, free rolling.

ACCURATE ROLL ALIGNMENT. Formed steel brackets and foot straps are held in place in a jig and welded to inverted angle base to provide accurate roll alignment. No bolts to shear or loosen.

BRACKETS CAN'T SPREAD. Yoke contour and slot on shaft lock all brackets together in a rigid truss structure. Even under unusually strong impacts, this sturdy arrangement prevents spreading of brackets.

AIDS BELT ALIGNMENT. Slotted holes permit positioning of idler to compensate for structure variations and to allow for training of the belt. Two bolts in each foot strap give greater stability and rigidity.



GREASEABLE TYPE has triple-labyrinth metal seal giving mechanical protection to moving parts while keeping grease in and dirt out.

FACTORY-SEALED TYPE consists of flexible synthetic rubber lip seal bonded to metal backing. No further lubrication is required.

- **Initial and long-lasting economies**
- **Low power requirements**
- **Smooth, free rolling**

HERE'S a new idler designed for belt conveyors carrying medium loads or for intermittent operations. It's the new Link-Belt Series 50 which takes its place in industry's most comprehensive belt conveyor idler line.

Backed by Link-Belt's vast engineering and manufacturing knowledge and experience in designing complete belt conveyor systems, the Series 50 is a self-contained, well-balanced unit with bearings fully enclosed and protected. The roll consists of a smooth, uniformly thick outer shell plus a heavy-wall steel center tube brazed to dished steel heads, forming a strong, moisture-proof, integral unit. Ends of the outer shell are counter-bored, and the center tube is journalled concentrically to assure roll alignment.

For data on the Series 50, write for Folder 2516. Your Link-Belt office or authorized stock-carrying distributor will also give you all the facts along with Book 2416 on the complete Link-Belt idler line.

LINK-BELT

BELT CONVEYOR IDLERS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,080

Results
you can get
by brushing
metals
are virtually
infinite*

Metal industries find Osborn Power Brushing opens totally new and unlimited opportunities to achieve qualities of finish and rates of production never before realized.

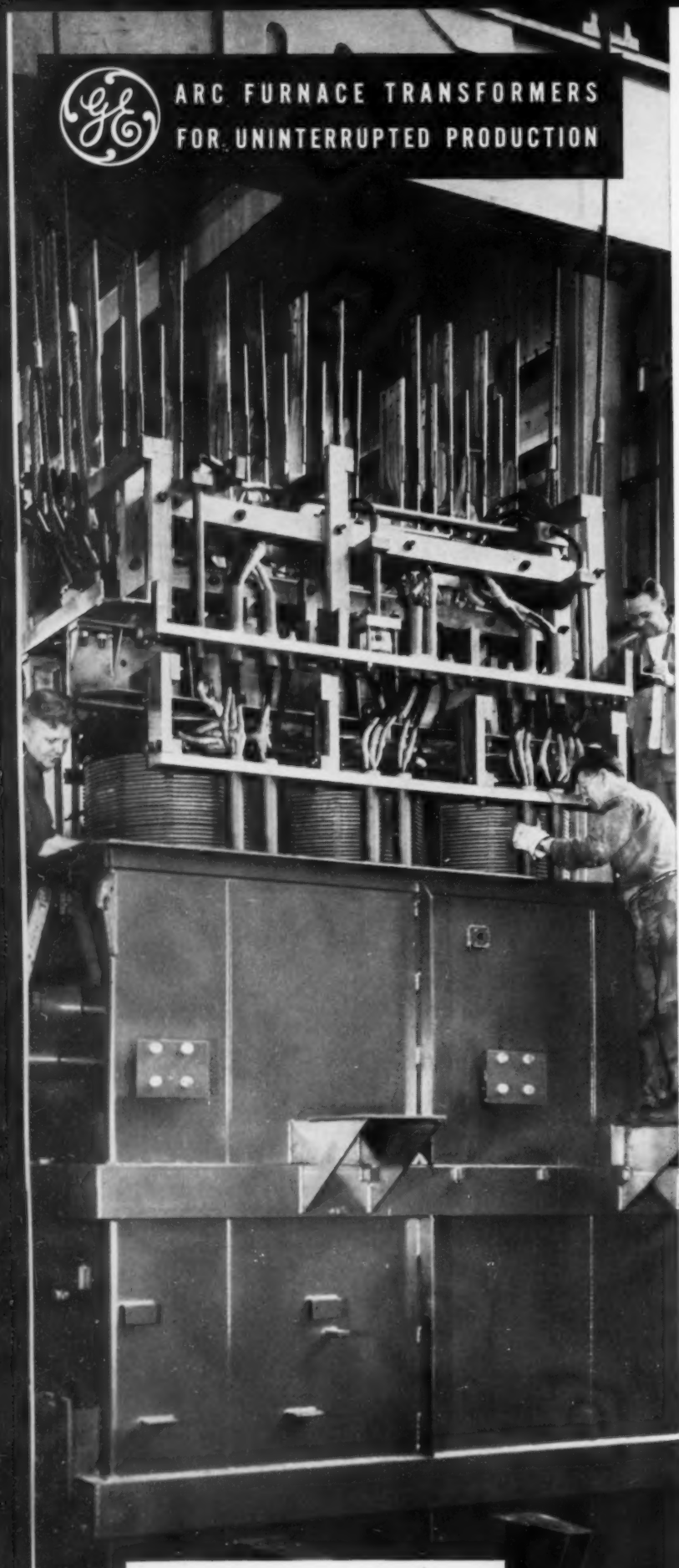
Osborn has pioneered the use of brushes as finishing tools. . . has engineered and developed virtually all the major improvements in power brushes, brushing methods and machines.

Improve your metal finishing processes with Osborn Power Brushing. Write *The Osborn Manufacturing Company, 5401 Hamilton Ave., Cleveland 14, Ohio.*

PIONEER IN THE BRUSHING OF METALS

OSBORN

Brushing Machines
Brushing Methods
Brushes
Foundry Equipment



MORE DEPENDABLE TRANSFORMERS: Core-type construction with circular-concentric windings makes G-E transformers best able to withstand the innumerable jolting forces encountered in arc-furnace operation.

G-E transformers keep your furnaces on the job

HERE'S WHY:

TREMENDOUS AND FREQUENT current surges during the meltdown period subject the windings and core clamps of furnace transformers to severe pounding stresses found in no other transformer application. The low-voltage bar-lead structure may also be subjected to forces more than 1000 times those encountered in normal power-transformer operation. General Electric Arc-Furnace Transformers are designed and built especially for this rugged service.

INHERENTLY STRONGER. Circular-concentric windings, used in all G-E transformers, are inherently stronger than other designs. A circular coil is far better able to withstand radial stress (the kind imposed by current surges), than a coil of any other shape. These coils are kept in place by a sturdy clamping structure, to prevent any shifting or deformation which could lead to failure.

GREATER STRENGTH is only one of many reasons why you should specify G-E transformers for your next arc-furnace installation. Others include: better cooling for more accurate control of hotspots, and a superior tap changer which has proved itself by a record of no contact-tip failures in over eighteen years.

For the full story, contact your nearest G-E Apparatus Sales Office or write to General Electric Company, Section 422-28, Schenectady 5, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC

T. J. ESS, *Editor*
I. E. MADSEN, *Associate Editor*
W. C. FRIESEL, *Advertising Manager*
T. A. KOCIS, *Production Manager*

Board of Directors

PRESIDENT
W. H. COLLISON
Plant Superintendent
Blast Furnaces and Coke Works
Great Lakes Steel Corp.
Ecorse, Mich.

FIRST VICE PRESIDENT, J. D. O'ROARK, *Assistant Manager,* Department of Service & Maintenance, Electric, Weirton Steel Co., Weirton, W. Va.

SECOND VICE PRESIDENT, LEONARD LARSON, *Chief Engineer,* Republic Steel Corp., Cleveland, Ohio.

TREASURER, EMIL KERN, *Vice President, Engineering,* Allegheny Ludlum Steel Corp., Brackenridge, Pa.

SECRETARY, S. C. READ, *Director, Construction and Maintenance,* Jones & Laughlin Steel Corp., Pittsburgh, Pa.

PAST PRESIDENTS: E. L. ANDERSON, *Superintendent, Electrical Department,* Bethlehem Steel Co., Johnstown, Pa.

JOHN H. VOHR, *General Superintendent,* United States Steel Corp., Gary Steel Works, Gary, Ind.

HONORARY DIRECTOR: JAMES FARRINGTON, Steubenville, Ohio.

DIRECTOR-AT-LARGE: C. E. PRITCHARD, *Superintendent of Mills,* Alan Wood Steel Co., Conshohocken, Pa.

DIRECTORS: F. R. PULLEN, *Fuel Engineer,* Bethlehem Steel Co., Johnstown, Pa.

F. T. VAN CAMP, *General Night Superintendent,* Colorado Fuel & Iron Corp., Buffalo, N. Y.

W. A. MARSHALL, *Works Engineer,* United States Steel Corp., Columbia-Geneva Steel Division, Pittsburg Works, Pittsburg, Calif.

N. R. KIRKDOFFER, *Superintendent, Power and Steam Departments,* Inland Steel Co., East Chicago, Ind.

C. E. DUFFY, *Fuel Engineer,* Bethlehem Steel Co., Sparrows Point, Md.

N. L. ARMITAGE, *Assistant Superintendent, Blooming Mill,* Granite City Steel Co., Granite City, Ill.

E. C. McDONALD, *Chief Combustion Engineer,* Republic Steel Corp., Cleveland, Ohio.

ROBERT SERGESON, *Chief Metallurgical Engineer,* Rotary Electric Steel Co., Detroit, Mich.

J. B. WHITLOCK, *Chief Maintenance Engineer,* Armco Steel Corp., Middletown, Ohio.

G. A. HENDERSON, *Superintendent, Rolling Mill Division,* Bethlehem Steel Co., Lackawanna, N. Y.

EMMET A. MAYHALL, *Electrical Engineering Department,* United States Steel Corp., Tennessee Coal & Iron Division, Fairfield, Ala.

D. N. EVANS, *Assistant Superintendent, Field Forces Department,* Inland Steel Co., East Chicago, Ind.

A. J. F. MacQUEEN, *Electrical Superintendent,* Algoma Steel Corp., Ltd., Sault Ste. Marie, Ontario, Canada.

J. N. IMEL, *Superintendent, Continuous Strip and Sheet Department,* Jones & Laughlin Steel Corp., Pittsburgh, Pa.

W. W. JUSTICE, *Chief Engineer,* United States Steel Corp., Youngstown, Ohio.

HAROLD C. HOEFT, *District Manager,* Stran Steel Corp., Oklahoma City, Okla.

Managing Director
T. J. ESS
Empire Building
Pittsburgh, Pa.

Iron and Steel Engineer

JULY, 1956 VOLUME XXXIII NUMBER VII

In This Issue

Patent Reviews — By Melvin Nord, Patent Attorney, Detroit, Mich..... 21
Crops and Shorts..... 49
Modernizing the Hot and Cold Strip Mills at Bethlehem's Lackawanna Plant — By F. S. Eckhardt, Chief Engineer, Bethlehem Steel Co., Lackawanna, N. Y..... 55
Heating Heavy Sections — How Fast? — By Quentin M. Bloom, Project Engineer, Selas Corp. of America, Philadelphia, Pa..... 66
Short Circuit Protection of Low Voltage Motors and Starters — By K. S. Kuka, Assistant Chief Engineer (Electrical), Tata Iron & Steel Co., Ltd., Jamshedpur, India..... 78
Tentative Program — 1956 AISE Annual Convention and Exposition..... 87
Layout and Design of Ingot Mold Foundries — By Glenn W. Merrefield, Foundry Engineer, Giffels & Vallet, Inc., Detroit, Mich..... 91
Welded Structures in Cranes and Mill Equipment — By I. W. Evans, Chief Welding Engineer, The Morgan Engineering Co., Alliance, Ohio.... 105
Power Requirements and Selection of Electric Equipment for Hot Strip Mills — By R. E. Marrs, Steel Mill Engineer, Systems Application Engineering Section, General Electric Co., Schenectady, N. Y..... 111
Automatic Weighing in the Steel Industry — By Robert A. Voll, Western Branch Manager, Streeter-Amet Co., Los Angeles, Calif..... 126
Replacement of Inland's No. 2 Blooming Mill — By A. L. Schroeder, Superintendent, Field Forces Dept., Inland Steel Co., East Chicago, Ind... 130
Modern European Hot Blast Changing Equipment — By Herman Jansen, Vice President of Operations, Zimmerman & Jansen, Dueren, Rhineland, Germany..... 137
American Iron and Steel Institute 64th General Meeting:
Principles of a Metallurgically and Physically Balanced Hot Strip Mill — By M. Alexander Leishman, Works Manager, Hamilton Works, The Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada..... 144
Metallurgical Aspects in the Design and Operation of a New Continuous Annealing Line — By A. F. Mohri, Chief Metallurgist, The Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada..... 148
Blast Furnace Oxygen Operations — By Julius H. Strassburger, Assistant Vice President, National Steel Corp., Pittsburgh, Pa..... 154
Steel's Depreciation Problem — By Benjamin F. Fairless, President, American Iron and Steel Institute, New York, N. Y..... 158
Can Maker Expands Research Facilities..... 162
The Boiler House — The Steel Plant's Heart — By George F. Wolfe, Chief Project Engineer, Dravo Corp., Pittsburgh, Pa..... 165
Date-line Diary..... 173
Industry News..... 183
Personnel News..... 201
Equipment News..... 223
Book Reviews..... 234
Applications for AISE Membership..... 238
Index to Advertisers..... 253

Published Monthly by

ASSOCIATION OF IRON AND STEEL ENGINEERS
1010 EMPIRE BUILDING
PITTSBURGH 22, PENNSYLVANIA

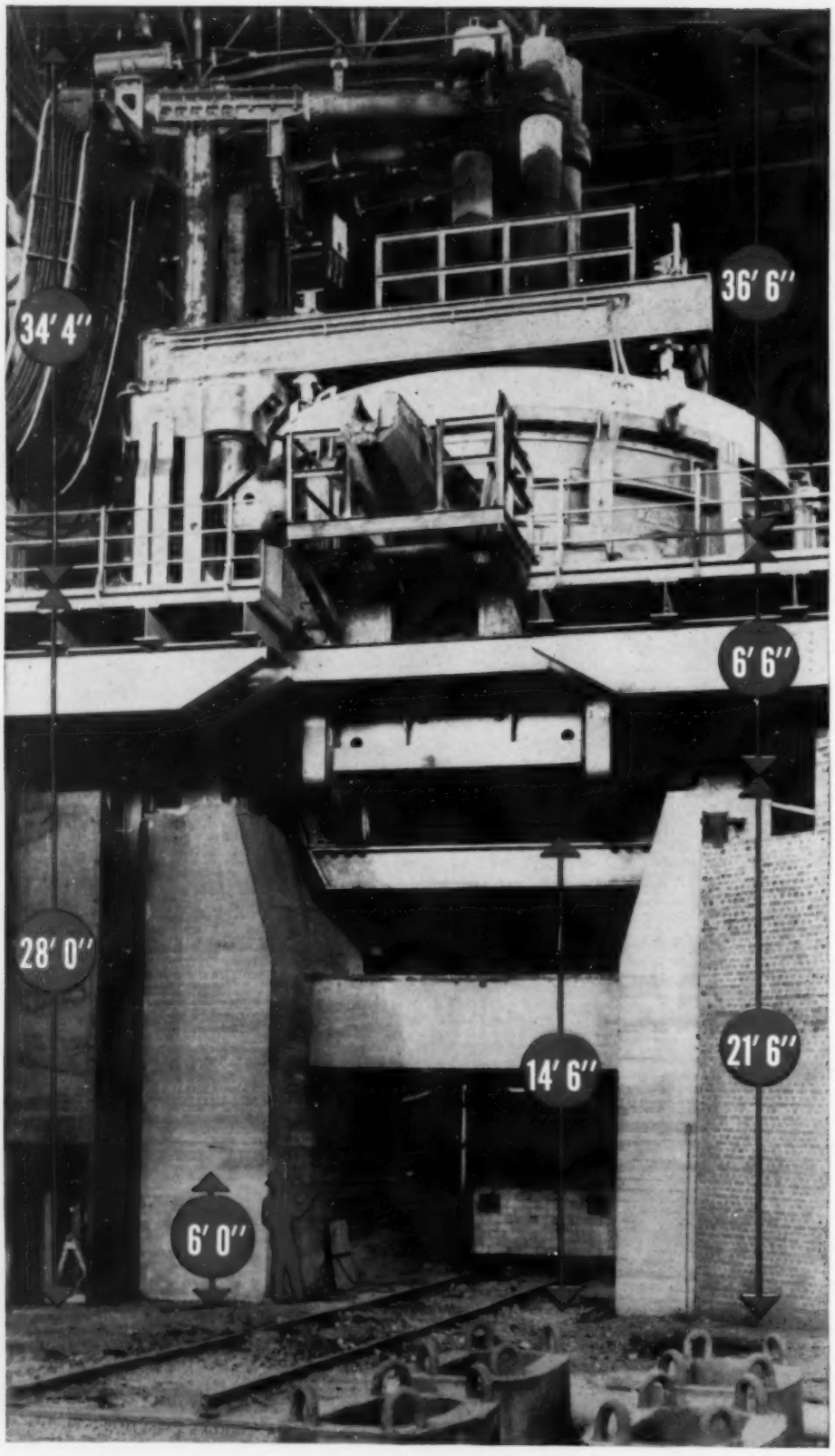
Statements and opinions given in articles and papers appearing in "Iron and Steel Engineer" are the expressions of contributors, for which the Association of Iron and Steel Engineers assumes no responsibility.

Copyright, 1956, The Association of Iron and Steel Engineers.

Indexed by Engineering Index and by Industrial Arts Index.

Single Copy Foreign Prepaid $2.00 (U. S. funds) Single Copy $1.50
Subscription price in U. S. and Canada (U. S. funds)... $ 7.50 per year
Subscription price in foreign countries (U. S. funds) ... $10.00 per year

PLASTIC BINDING U. S. PATENT NO. 1970285 LICENSE NO. 128



The most **POWERFUL** steel melting furnace operating in the world today is a **LECTROMELT***

6 others of even greater power are now under construction

For Catalog 9B describing these furnaces, write Lectromelt Furnace Company, 310 32nd Street, Pittsburgh 30, Pennsylvania (a McGraw Electric Company Division).

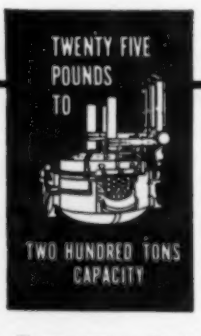
Compare the dimensions of this giant Lectromelt Furnace at Fabrique de Fer, Charleroi, Belgium, with those of the 6-foot man sketched alongside.

Manufactured in . . . ENGLAND: Birlec, Ltd., Birmingham . . . FRANCE: Stein et Roubaix, Paris . . . BELGIUM: S. A. Belge Stein et Roubaix, Bressoux-Liege . . . SPAIN: General Electrica Espanola, Bilbao . . . ITALY: Forni Stein, Genoa . . . JAPAN: Daido Steel Co., Ltd., Nagoya

*REG. T. M. U. S. PAT. OFF

MOORE RAPID

WHEN YOU MELT... *Lectromelt*



Modernizing the Hot and Cold Strip Mills at Bethlehem's Lackawanna Plant

By F. S. ECKHARDT, Chief Engineer, Bethlehem Steel Co., Lackawanna, N. Y

▲ IN 1935 the Bethlehem Steel Co. built at its Lackawanna plant, a 79-in. wide hot and cold strip mill. The mills were very similar to a half dozen other mills that were built by the industry at about the same period, insofar as overall design, rated capacity, range and type of products were concerned.

The advent of a number of these wide mills, together with their capacity to produce large quantities of sheet products, and the rapid advance in the usage of the products, resulted in an equally rapid expansion of the market. These factors very quickly changed the pattern and tonnage of sheet orders the mills were expected to produce.

As a result of the large increase in demand for sheet steel, plus a comparatively rapid change in specifications, the wide strip mills, as built in the early 1930's, were by present day standards, obsolete in many respects before the paint was scarcely dry on the new construction.

Almost as soon as the Lackawanna mill was in operation, a series of somewhat minor changes were made to the equipment to meet the new pattern of orders and reduce operating costs, and machinery and equipment were added in an attempt to keep pace with the rapidly expanding market. It is not the intent of this paper to discuss each of the changes in detail, but rather to give the end result of a 20-year modernization program that culminated with two major construction projects authorized in 1949 and 1951.

The original Lackawanna mill was built to produce 50,000 net tons per month of hot rolled bands, of which 20,000 net tons per month were to be converted into cold reduced sheets. As a result of the two major modernization programs, plus a number of lesser improvements made during the interim from 1935 to 1949, the capacity of the hot mill is now rated at over 200,000 net tons per month of bands. Likewise, the cold mill facilities have been increased to provide for the manufacture of 150,000 net tons per month of cold rolled sheets. Recent production performances for a period of several months show that the new capacity figures can be easily met by the revamped mills.

The original layout of the mills has been quite widely publicized and needs no detailed description here; however, the writer will try to give a resume of the major alterations that have been made to obtain the increase in productive capacity.

The hot mill, which will be discussed first, was originally a 10-stand, 79-in. wide mill, having a train of four 4-high roughing mills followed by a train of six 4-high finishing stands. There was a 2-high scale breaker in front of each train. The mills were designed to

Hot mill capacity has been increased over four times and cold mill capacity almost eight times at the Lackawanna Plant of Bethlehem Steel . . . . these remarkable improvements have been accomplished with minimum delays to production, at reasonable costs and yet provide an operation whose production costs are comparable with mills 20 years younger.

straight roll slabs up to 48-in. wide by 4½ in. thick by 192 in. long, weighing 11,800 lb maximum. All wide sheet products between the 48 and 72-in. width range were to be made by the conventional cross-rolling method from slabs 48 in. wide by 4½ in. thick by 87-in. long, weighing 5300 lb. Hot mill products that subsequently were to be cold reduced were coiled.

Practically all of the finished hot rolled sheets were cut to multiple lengths on the mill flying shear, hot piled and, after cooling, reprocessed through sheet trimming lines into final, finished, hot rolled sheet sizes. Virtually all cold reduced sheets were processed and shipped as sheets, since there was very little demand by the trade for finished, cold rolled sheets in coils.

Today the hot mill produces hot rolled bands up to 63-in. finished width by straight rolling slabs 64-in. wide and up to 208-in. long, in thicknesses varying

from 5½ to 7½ in., weighing a maximum of 20,000 lb. Sheet and coil products in the width ranges of 63 to 74-in. are still made by the cross-rolling method, but the slab thickness has been increased from 4½ to about 6-in.

The changes that have been made at the hot strip mill and in the balance of the plant are as follows:

SLABS

All slabs produced at Lackawanna are rolled on conventional high-lift blooming mills, which in 1935 were limited to the manufacture of slabs of 50 in. maximum width.

In 1950, the 54-in. blooming mill was rebuilt to increase the lift of the rolls to 68½ in., permitting it to roll wider ingots and finish a 64-in. wide hot slab.

In 1953, the 44-in. blooming mill was also changed to increase the lift of the rolls to 60 in., permitting it to finish 55 in. wide hot slabs.

SLAB STORAGE AND PREPARATION

Two slab yards have been provided for slab storage and preparation. One was the original covered building; 85 x 925-ft, the second an open yard, parallel and adjacent to it, 100 x 725-ft, was added in 1940. In 1953, to handle the increased slab inventory necessary for the higher production rates and also to improve the layout for the surface preparation of slabs, the open yard was covered. Two small, narrow scarfing beds originally built in the covered yard, adjacent to the reheating furnaces, were abandoned. One new scarfing bed, 40 x 375-ft, with two new, larger gantry cranes was constructed in the 100-ft span yard. All slabs as received from the blooming mills are now stocked in the 100-ft span yard, surface prepared, and transferred to the 85-ft span yard for stocking ahead of the furnaces.

This arrangement did much to correct a very bad material flow, reduce congestion in the slab yards, increase hand scarfing rates, and, with the new furnace charging magazine, virtually eliminated furnace charging delays. Slab inventory stocked in these two yards now ranges from 60,000 to 70,000 tons.

SLAB REHEATING FURNACES

Very early in the life of the hot strip mill, slab reheating capacity proved to be the bottleneck in the production of the mill. With the three original furnaces, rated at 55 net tons heating capacity per hour, the mill production was limited to about 90,000 to 100,000 net tons of bands per month maximum, with our pattern of orders.

The first change to eliminate this bottleneck was the installation of a fourth reheating furnace, having a hearth size of 18 x 80-ft, a duplicate of the three original furnaces. This intallation was made late in 1946. Mill production was increased to about 120,000 net tons per month after its completion.

Following the improvements made to the mill train in 1950 to increase rolling capacity, the four furnaces again proved to be the limiting factor in mill production. Consequently, in 1953, all four furnaces were further modernized and the heating capacity of each was increased to over 100 net tons per hour. This modernization program included a new metallic recuperator for each furnace, giving an air preheat of 650 F; a new induced draft Venturi stack to produce an effective draft of 2 in. of water, and a larger combustion air fan.

In addition, minor changes were made to the skid pipe arrangement, and the combustion volume of the top and bottom heating zones was increased by minor brickwork modifications.

The combined effect of these changes permitted satisfactory firing rates up to 1200 gallons of oil per hour per furnace.

In addition to the combustion changes, the thickness of the refractory sidewalls of the furnace proper was reduced from 18 to 10 in. This gave the advantage of increasing the length of the slabs that could be pushed through the furnace from 192 to 208 in. Figure 1 shows a diagrammatic comparison of the original 55-tons per hr furnace and the general contour of the rebuilt 100-tons per hr furnace with metallic recuperator.

With the four rebuilt furnaces and faster rolling rates, the original slab magazine piler serving the furnace charging table was not adequate and caused frequent furnace charging delays. To correct this situation a new roller-type slab magazine with 70 ft of supply table ahead of it was installed as part of the overall program.

HOT MILL TRAIN

A study of the hot mill rolling and production schedule showed quite conclusively that the number of pieces that could be rolled per hour, or per turn, was one of the major controlling factors on mill tonnage. When it is considered that the mill was rolling over 45,000 pieces of steel per month in the form of slabs, it is quite obvious that any gain that could be made in the unit slab weight would be one of the best ways to increase the mill's overall tonnage.

The length of the slabs used was, of course, fixed by the width of the furnace hearth. The limitation in using thicker slabs proved to be primarily the clear space that was available for elongation of the slab between the four roughing-mill stands and between the last roughing-mill stand and the finishing train. In order to produce hot rolled bands of the desired finished gage, with the drafts that could be taken in the original 10-stand mill, the thickness of the slabs entering the first roughing stand was limited to about 4½ in. Entering the finishing train, the bar thickness was in the range of about ¾ in.

To avoid a very costly and time-consuming rearrangement of the roughing mills in order to provide more clear space between them, similar to the layout of the more modern hot-mills, a different method of approach was chosen to increase the unit slab weight.

In 1950 a seventh 4-high mill stand was added to the finishing train, after the last finishing stand. The extra stand permitted the mill operators to enter the finishing train with a thicker bar from the roughing train, and still make a product of the desired finished gage.

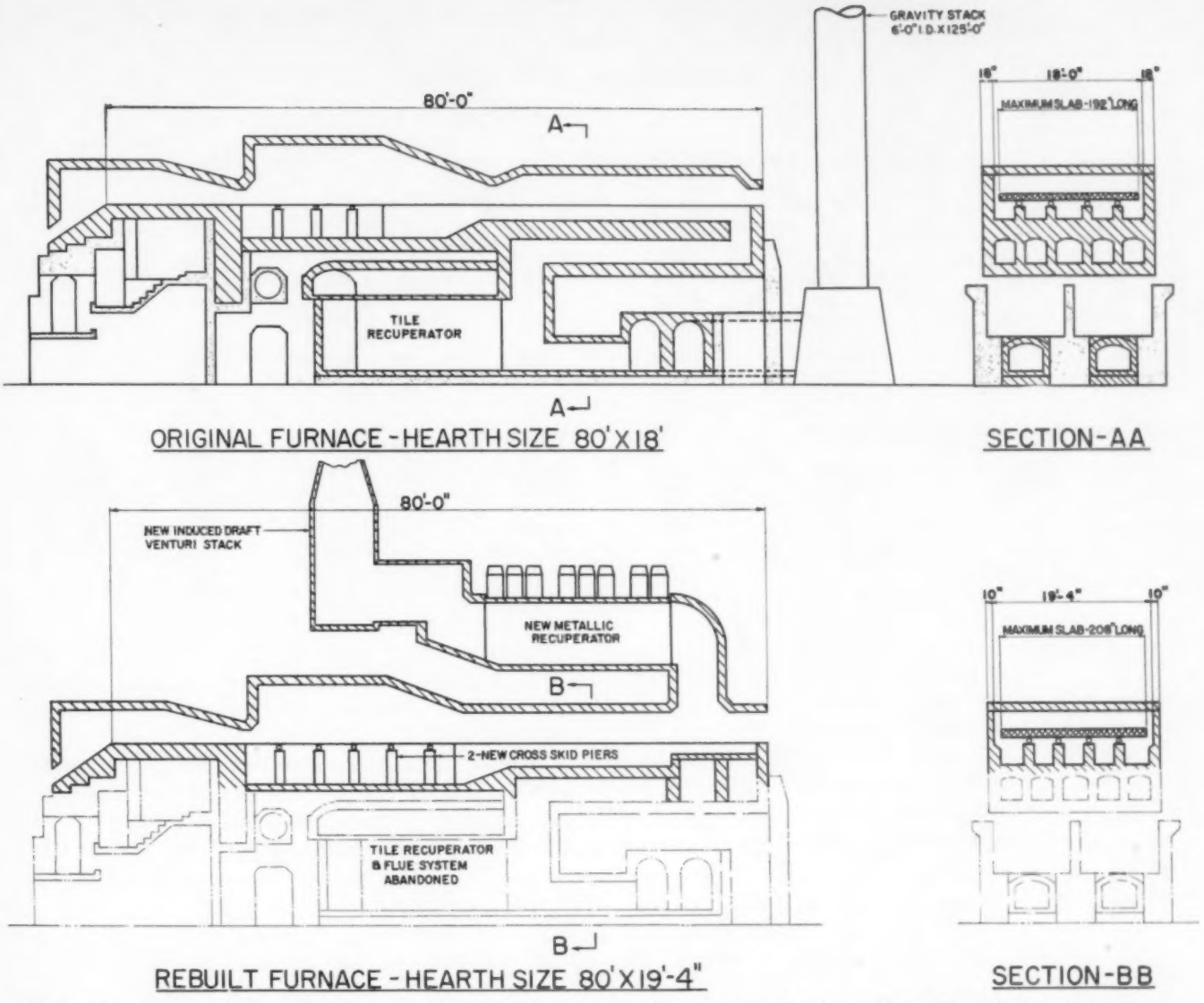


Figure 1 — Slab heating furnaces were increased in size to give a longer slab by cutting down lining thicknesses. Metallic recuperators were also added.

Incidentally, this arrangement also offered the advantage of a higher delivery speed from the finishing train.

By entering the finishing train with a thicker bar, the amount of draft that would have to be taken in the roughing mills would be automatically reduced, assuming the original 4½ in. slab thickness were maintained. A further study of the roughing mill drafts and horsepowers showed that by replacing one of the 24 & 49 x 79-in. 4-high mills with a heavier mill stand, driven by a larger motor, it would be possible to change the drafts in the four roughing mills and permit the thickness of the entering slab to be increased to 5½ to 7½ in. —depending upon the width. With the thicker slab, the length of the product coming out of each roughing mill still would not exceed the clear length between the roughing mill stands.

No. 3 mill stand was removed and a new 30 & 49 x 79-in. mill stand erected on the same shoes. The new mill stand also had a more powerful, integral edging stand with a 300-hp drive. The old 3000-hp a-c mill drive motor was replaced with a new 4500-hp, a-c motor and gear reduction.

To improve the other space limitation problem that existed between the roughing and finishing trains, the 2-high scalebreaking stand that had been installed ahead of the finishing train, was removed. In place of the scalebreaker, a rotary crop shear and a new driven pinch roll were installed.

Table I compares the mill speeds and motor horsepowers of the original mill, and also for the revamped arrangement. The changes are indicated in boldfaced type.

It might be of interest to state that the hot mill was out of production only 16 days, while the new mill stands and drives were being installed.

The result of these changes, including the greater slab length made possible by the change in the reheating furnace sidewalls, increased the unit slab weight 60 per cent on products made from slabs that could be straight rolled, and 33 per cent on cross-rolled slabs for sheet production in the 62 to 74-in. width range.

With the increase in finishing speed obtained by the addition of the seventh stand to the finishing train, the mill runout table to the coilers likewise had to be modified. The original table had rollers spaced at 36-in. centers, with solid aprons between the rollers. With this design it proved to be very troublesome to provide adequate water cooling on the strip ahead of the coilers.

TABLE I

Bethlehem Steel Co. — Lackawanna Plant

79-In. Hot Strip Mill

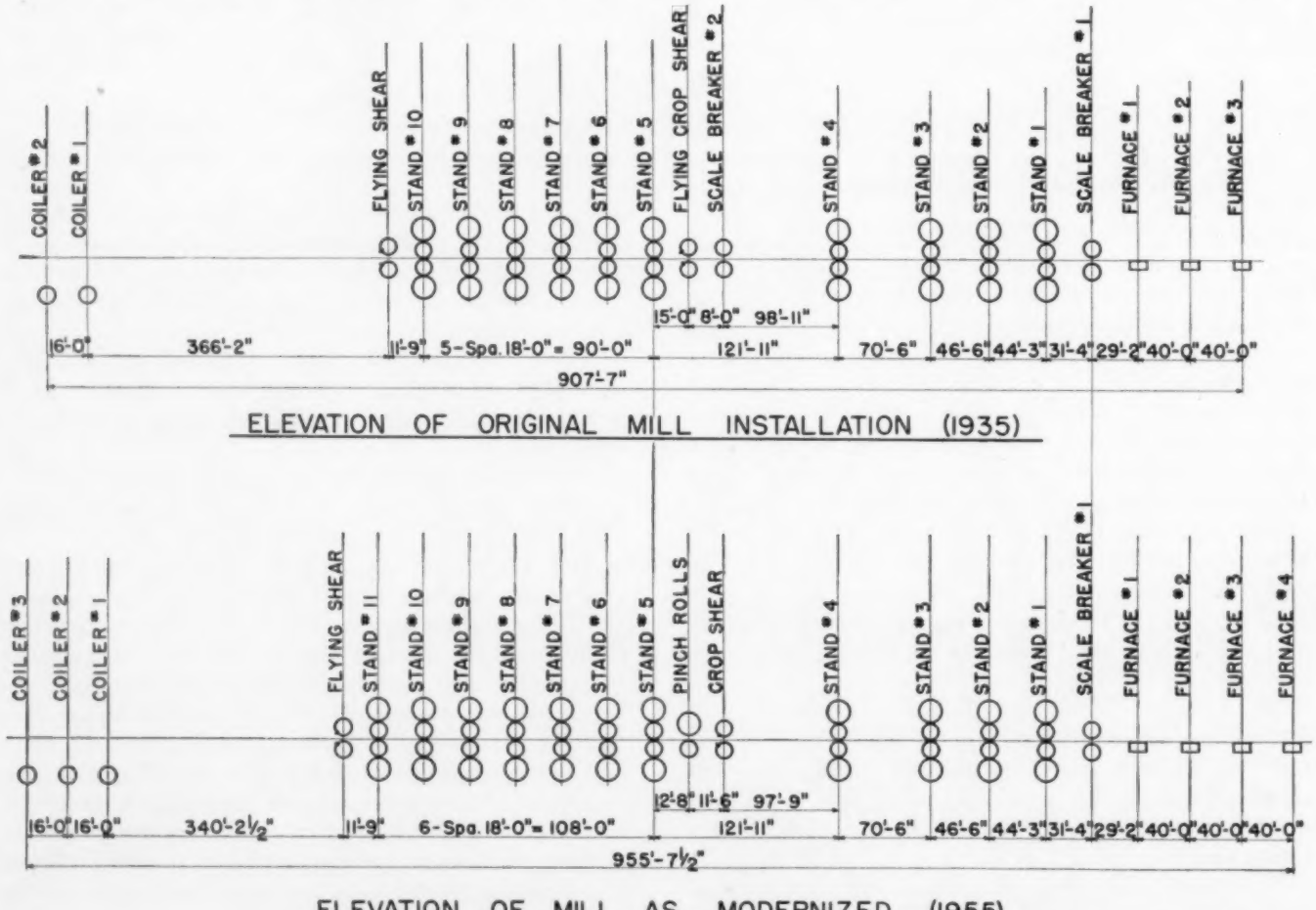
	Original mill installation (1935)			Mill as modernized (1955)		
	Mill size, in.	Motor hp	Mill speed (fpm)	Mill size, in.	Motor hp	Mill speed (fpm)
Scale Breaker No. 1 — 2-High	24 x 79	1000	282	24 x 79	1700	282
Stand No. 1 — 4-High	36 & 49 x 96	3000	180	36 & 49 x 96	3000	180
Edger No. 2	20	150	....	20	150	....
Stand No. 2 — 4-High	24½ & 49 x 79	3000	411	24½ & 49 x 79	3000	411
Edger No. 3	20	150	....	24	300	....
Stand No. 3 — 4-High	24½ & 49 x 79	3000	411	30 & 49 x 79	4500	423
Edger No. 4	20	150	....	20	150	....
Stand No. 4 — 4-High	24½ & 49 x 79	3000	411	24½ & 49 x 79	3000	411
Scale Breaker No. 2 — 2-High	24 x 79	500	90/360			
Pinch Roll	.....	....	....	18.5	300	151/320
Stand No. 5 — 4-High	24½ & 49 x 79	3500	177/354	24½ & 49 x 79	3500	177/354
Stand No. 6 — 4-High	24½ & 49 x 79	3500	280/561	24½ & 49 x 79	3500	280/561
Stand No. 7 — 4-High	24½ & 49 x 79	3500	381/762	24½ & 49 x 79	3500	381/762
Stand No. 8 — 4-High	24½ & 49 x 79	4500	483/966	24½ & 49 x 79	4500	483/966
Stand No. 9 — 4-High	24½ & 49 x 79	4500	590/1180	24½ & 49 x 79	4500	590/1180
Stand No. 10 — 4-High	24½ & 49 x 79	2500	676/1352	24½ & 49 x 79	4500	758/1515
Stand No. 11 — 4-High	.....	....	....	24½ & 49 x 79	3500	990/1980

The original table was scrapped and a more modern table, with rollers at 18-in. centers, was installed. Speed changes on the table were obtained by altering the original variable frequency control.

In order to cool the strip before coiling, a complete new water-spray system was provided on the runout table, with both top and bottom sprays at 125 psi. Recent checks show that we are pumping water at a rate of over 400,000 gphr through the runout table spray system.

One new coiler was installed and the two original units completely rebuilt. The new mill has three coilers

Figure 2 — One of the unusual features of the new hot mill is the additional seventh stand in the finishing train.



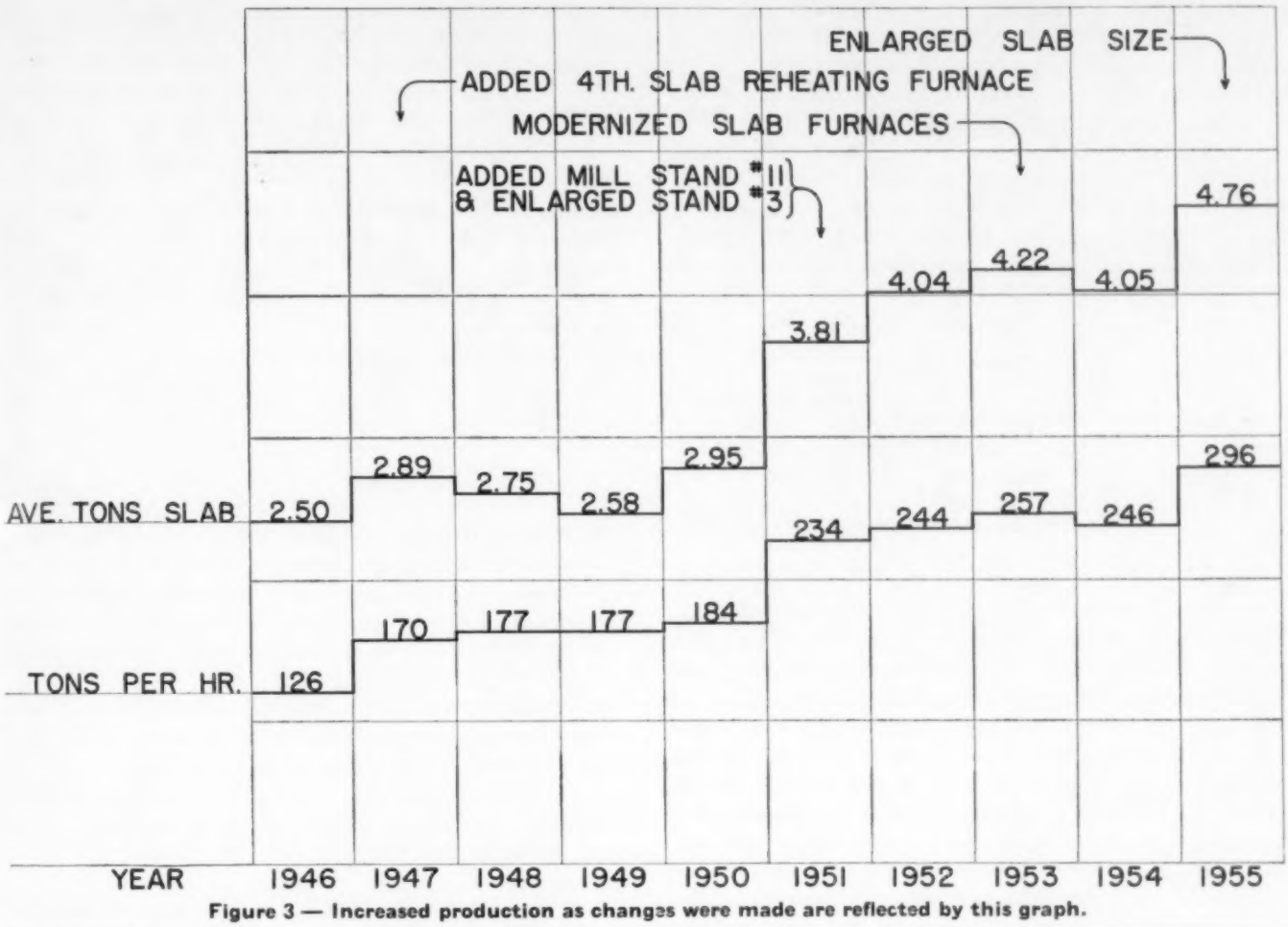


Figure 3 — Increased production as changes were made are reflected by this graph.

capable of handling coils up to about 450 lb per in. of width, 26 in. inside diam x 54 in. outside diam. All coilers are of the stationary mandrel type. A new coil-transfer buggy was necessary for the three-coiler arrangement, and the chain carrying the coils away from the mill was speeded up to about 16 fpm. Figure 2 shows a comparison of the arrangement of the complete mill train as originally built, and the new arrangement with the 7-stand finishing train, four furnaces and three coilers.

HOT STRIP FINISHING DEPARTMENT

Over the years many improvements of a minor nature have been made in the hot strip finishing and processing equipment. Without going into the details of each, it will suffice to say that most of the modifications have been in the direction of processing finished hot rolled sheets from hot rolled bands, rather than from multiple cut-length piler material. At present, practically all hot rolled sheets $\frac{3}{16}$ in. and less in thickness are produced from hot rolled coils. The heavier gages and lighter plates are produced from the multiple-length piler product.

There was a bit of doubt even among some of our own people whether the 7-stand finishing train would be a good mill rolling proposition. It has now been in use for over four years, and the operators state they would not want to go back to the 6-stand finishing mill even if the slabs to be rolled were only $4\frac{1}{2}$ in. thick. There are fewer cobbles, mill rundown is better, and the metallurgical advantages of being able to enter the finishing train with a heavier, hotter bar has proved to be very desirable for our type of product.

Figure 3 shows graphically a comparison for the years 1946 to 1955 inclusive, of the unit slab weights and the average tons per hour that have been rolled on the mill. Each of the major changes that have been described shows quite clearly the increase in tons per hour.

In 1946 the fourth slab furnace raised the average hourly tonnage 35 per cent.

In 1950 the mill-train change again raised average hourly tonnage 32 per cent.

In 1953 the completion of the furnace changes raised the average another 21 per cent.

The hot mill changes can be very briefly summarized as follows:

Slab thickness has been increased from a miximum $4\frac{1}{2}$ to $7\frac{1}{2}$ in. Unit slab weight has increased 91 per cent. Bar thickness entering the finishing train has been increased from an average of around $\frac{3}{4}$ to $1\frac{1}{16}$ in. Mill finishing speeds have been increased from 1350 fpm to 1980 fpm. Hot rolled coils have increased from a maximum of 250 lb per inch of width to about 450 lb per inch of width. Finished hot rolled sheets are now made from coils rather than from multiple-cut piler lengths. And most important, the average hourly mill tonnage has gone up from 126 to 296 tons per hr.

Table II shows the hot mill performance for the first five months of 1955 and includes the various mill records.

TABLE II

Bethlehem Steel Co. — Lackawanna Plant

79-In. Hot Strip Mill

Operating Performance — January Through May 1955

Month	January	February	March	April	May
Average tons per hour	287	286	303	307	285
Average slab weight (net tons)	4.52	4.69	4.95	4.87	4.94
Production in net tons of bands	195,236	178,717	211,179	203,834	193,651

	Net tons
Monthly record	211,179
Weekly record (20 turns)	52,181
24-Hr record	10,381
8-Hr Record	3,719
1-Hr record	520

COLD MILL DEPARTMENT

In the cold mill department the changes and additions have been generally more extensive than those in the hot mill, for two primary reasons. The first is the change that came in the method of processing cold rolled sheets. In the original mill installation, after the pickling and cold reducing operation, the cold rolled sheets were largely processed through the subsequent steps as sheets, since practically all finished cold sheets were shipped in sheet form. Our mills had hardly been completed and placed in operation before it was evident that there were great operating economies to be attained by doing more of the cold mill processing steps in coils rather than sheets. Also there was a gradual but marked increase in the use of finished material in coil form, rather than in sheets, by the trade. This trend has continued to increase each year.

Numerous modifications were made to the cold mill processing units from 1935 to 1940 in an attempt to meet the changes in processing practice and customer requirements. Many of the alterations might be termed somewhat of the makeshift variety, since they were done in the most expeditious manner with what was at hand. It did not take long to find out that the revamped machinery designed originally for small 12,000-lb maximum weight coils could not be maintained with coils up to 70 in. in diameter and weighing about 65,000 lb.

The second major factor in the gain in cold mill tonnage was that the increase in the sale of cold reduced sheets was in a far greater proportion of the total strip tonnage than that of hot rolled sheets. This required major expansions to the cold mill processing units—particularly the annealing department—to increase their capacity.

Between 1949 and 1952 two major construction programs were completed in the cold mill department, to increase its capacity and correct the processing problems on the different units to accommodate the heavyweight coils. These changes are basically as follows:

CONTINUOUS PICKLERS

Automatic resistance welders replaced the original stitchers, and better scalebreaking devices were in-

TABLE III

Bethlehem Steel Co. — Lackawanna Plant

Cold Reducing and Skin Pass Mills

	Original mills (1935)			Revamped mills (1955)		
	Size of mill, in.	Motor hp	Mill speed (fpm)	Size of mill, in.	Motor hp	Mill speed (fpm)
75-in. Tandem Mill						
Stand No. 1 — 4-High	20 & 49 x 75	1250	150/300	20 & 49 x 75	2500	480/1068
Stand No. 2 — 4-High	20 & 49 x 75	1250	270/494	20 & 49 x 75	4000	668/1335
Stand No. 3 — 4-High	20 & 49 x 75	1250	310/620	20 & 49 x 75	4000	854/1709
Stand No. 4 — 4-High	.....	....	.....	20 & 49 x 75	4000	961/2200
54-in. Tandem Mill						
Stand No. 1 — 4-High	20 & 49 x 54	1250	150/300	20 & 49 x 54	2000	484/1209
Stand No. 2 — 4-High	20 & 49 x 54	1250	270/494	20 & 49 x 54	3500	806/1612
Stand No. 3 — 4-High	20 & 49 x 54	1250	310/620	20 & 49 x 54	3500	1074/2417
Stand No. 4 — 4-High	.....	....	.....	20 & 49 x 54	3500	1343/2955
Skin Pass Mill No. 1 — 4-High	20 & 49 x 75	1250	311/621	20 & 49 x 75	1250	311/621
Skin Pass Mill No. 2 — 4-High	20 & 49 x 75	1250	311/621	20 & 49 x 75	1250	1611/2470
Skin Pass Mill No. 3 — 4-High	24 & 49 x 93	1250	180/360	24 & 49 x 93	1250	1885/2890
Skin Pass Mill No. 4 — 2-High	28 x 54	250	301/601	28 x 54	250	301/601
(1940) Skin Pass Mill No. 5 — 4-High	20 & 49 x 75	1250	640/1280	20 & 49 x 75	1250	1611/2470

stalled ahead of the two original pickling lines. A fifth acid tank was also added to each of the two lines. Speeds were increased, and one of the original lines now has an entering speed of 1200 fpm with a pickling speed of 450 fpm. Slitters were installed at the delivery end of the lines, and new recoilers, suitable for the 65,000-lb coils, replaced the original units.

In 1950 a third new continuous pickling line was installed, giving the plant three modern picklers. At the same time, the coil storage area ahead of the units was more than doubled and a better method of conveying the coils from the hot mill into storage and back from storage to the picklers, was installed. Currently, these pickler units are averaging about 80 tons per hr each.

TANDEM COLD REDUCING

Two 3-stand tandem mills—one a 20 & 49 x 54 in., the other a 20 & 49 x 75-in. unit, both operating at top speeds of 620 fpm, comprised the original cold reducing installation. In 1946 the 54-in. tandem mill had been increased to a 4-stand train, and at that time it was changed to about 1000 fpm delivery speed. Originally, both trains had been arranged very close together with their drives back-to-back. It was impossible to install larger drive motors in the space available to obtain any further increase in mill speeds and capacities.

In the overall revamping program, the 75-in. tandem train was moved about 150 ft from its original location to a new foundation, a fourth stand was added, and, with complete new motor drives, it was speeded up to 2200 fpm. While the 75-in. mill was being moved, it was out of operation for 13 calendar days.

After this move had been completed, the 54-in. mill drives were torn out, more powerful motors and new control were installed, utilizing the area previously occupied by the 75-in. mill. The delivery speed of the rebuilt 54-in. mill was fixed at 2955 fpm. This mill train was out of operation for 29 calendar days while the new drives and control were installed.

New feed and tension reels, together with adequate power conveyors to handle the coils around the mills, were added to each train. Each mill will now handle coils up to 70 in. outside diam x 900 lb per in. of width. At current production levels, these mill trains will average about 125 net tons per hr each.

Table III gives a comparison of the tandem mills speed and horsepower data as originally built, and as they are now. Also shown are similar data for the temper mills that will be outlined in detail later.

ANNEALING

The original annealing department had been built up over a period of several years to a group of fifty 75 x 220 in. and 90 x 250 in. radiant-tube fired, flat sheet annealing furnaces, and ten 4-stack coil furnaces.

While the old sheet furnaces were used for coils as well as for sheets in the processing stage, their production rate was obviously very low compared to the modern coil furnaces. In 1950, all but 22 of the old sheet furnaces were scrapped and replaced by 24 8-stack 70-in. diam by 148-in. high radiant-tube-fired coil furnaces, with 69 bases. All of the coil furnaces were erected in new buildings. The building space made available by tearing out the old sheet furnaces was utilized for coil cooling area ahead of the temper mills. The production from the new coil furnaces averages about 7 tons per hr on all grades of annealing, with about 70 per cent of this tonnage being in the deep-drawing quality. The 22 old sheet furnaces remaining are used for special sheet annealing, including hot rolled anneal, and will average about 1.1 tons per hr in capacity.

SKIN MILLS

Three 4-high and one 28 x 54 in. 2-high sheet skin mills comprised the original temper mill installation. All the mills operated at comparatively slow delivery speeds in the range of 350 to 620 fpm. One of the 4-high mills and the 2-high mill were also equipped with tension reels for handling coils up to a maximum weight of 12,000 lb. In 1940 a fourth 20 & 49 x 75 in., 1280-fpm coil skin mill had been added.

As part of the improvement program, three of the 4-high mills were speeded up to the range of 2500 to 2800-fpm delivery speed. The mill stands were equipped with suitable power conveyors on the entry end and large feed and tension reels to handle the maximum size 65,000-lb coils. The original 1250-hp drive motors were retained but complete new electrical control was installed. On the average, each of the 4-high coil skin mills is now producing between 65 and 75 tons per hr, depending upon width and gage.

CUTTING-UP LINES

Three sheet cutting-up lines had been set up originally to cut hard steel between the tandem cold reducing and sheet annealing operation. Three new cutting-up lines have since been installed, designed to cut up soft steel. Two of the original lines have been revamped and relocated for the same purpose. One of the original lines was transformed into a combination hard and soft steel line.

All lines are grouped into one department, equipped with power-driven conveyors throughout, adequate feed reels, reject pilers and automatic prime pilers. The cutting-up lines will average about 30 tons per hr each with our pattern of sheet sizes.

FINISHING EQUIPMENT

The usual type of finishing machinery has been installed to keep pace with the pattern of orders. Two modern, wide slitting and trimming lines, two smaller, narrow slitting lines, eleven resquaring shears for the sheet reclamation department, together with the usual stretcher levellers, oilers, etc., are now in use to handle the specialty business.

MATERIAL HANDLING

In the modern cold strip mill, material handling is an extremely important item—particularly since coil sizes and weights have increased so enormously in the

last 15 years. In our mills the use of all gravity-type conveyors for moving material has been practically eliminated. All conveyors used for feeding and discharging processing machinery and mill trains, and for transfer of materials from one building to another, are now power-driven and of the pallet type. They are used for both coil and sheet products.

The transfer of coils between the tandem cold reducing operation, the annealing department, and the skin pass mills is handled over a narrow-gage track system on 100-ton capacity cars. The trains of coil cars are hauled along the tracks by rubber-tired tractors.

Coils to be transferred between the skin mills, the cutting-up lines, slitters, and the shipping department are handled by heavy-duty diesel-electric ram trucks of 60,000-lb capacity. These trucks have a rather unique feature in that the ram is a split design so that the truck can carry either two small coils or one large coil. Sheet packs are handled inter-departmentally by the conventional automotive type of sheet carriers or by electric overhead traveling cranes equipped with modern pack carriers.

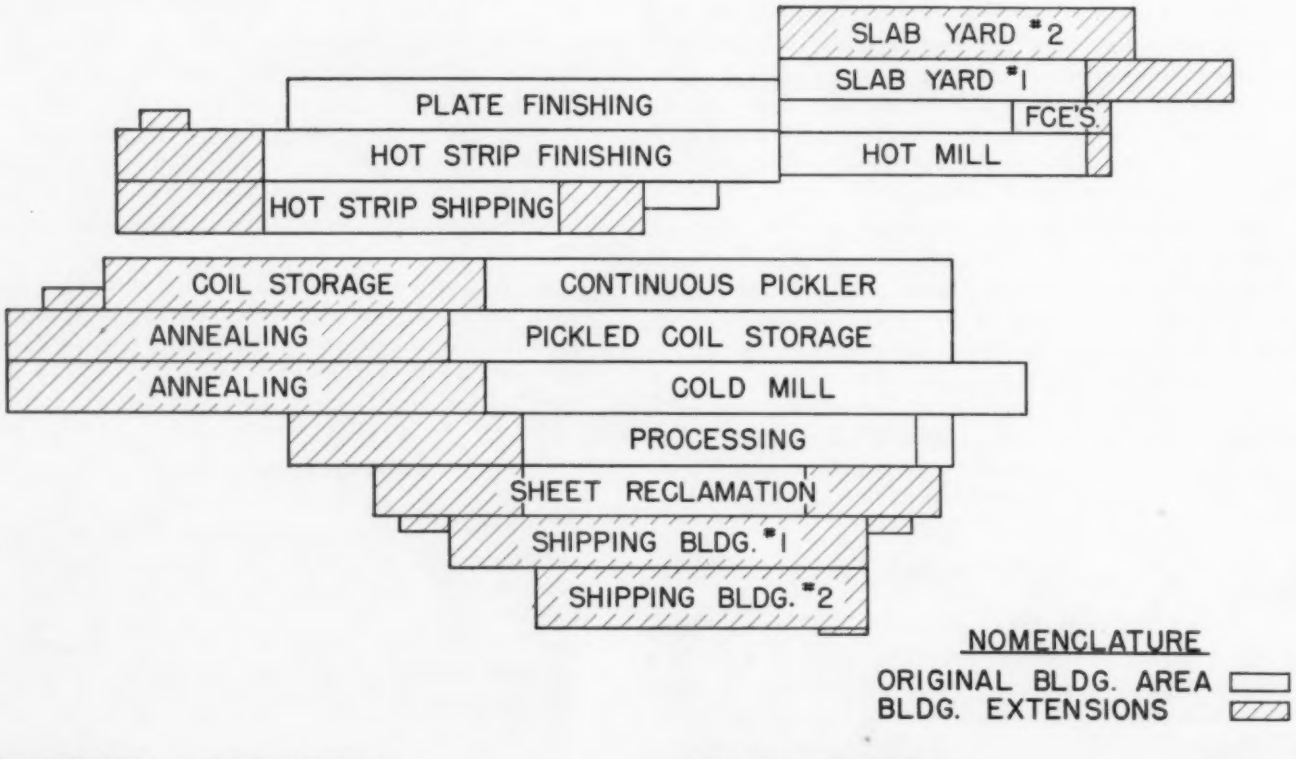
SHIPPING

With literally millions of pieces to be handled in the course of a year in the cold strip department, packaging and shipping not only require considerable building area, but these areas should be so located in relation to processing machinery that a minimum number of moves will be required to finally weigh, package, load and ship. Sizable floor areas are provided immediately adjacent to each of the sheet cutting-up lines for packaging and weighing. Finished packs are transferred by power conveyors to an adjacent building for either railroad or truck shipment. Special consideration was given to the size and location of truck-loading docks to provide for several trucks, at one time, in an area that can be serviced by several cranes simultaneously. In the concept of the shipping departments, one had been set up for sheets, in its own building, and a second for coils, in an adjacent building. The areas provided were predicated on a split of about 65 per cent of the shipments in the form of sheets, and 35 per cent in coils. Actually today the percentage is about reversed, and some of the coil shipping is now handled in the sheet shipping department.

BUILDING AREAS

Due to the rather phenomenal growth in sheet consumption, at least as compared to some other steel products, it is quite evident that some of the earlier mills, like the Lackawanna mill, came nowhere near having sufficient building space for the tonnages being handled today. In the original building program, there was 21 acres of buildings divided into 435,000 sq ft for the hot mill, and 476,000 sq ft for the cold mill. As of today, the hot mill has 629,000 sq ft in its group of buildings, and the cold mill 1,047,500 sq ft, a combined total of 39 acres.

Figure 4 — It was also necessary to provide more building area as production was increased.



1935 ORIGINAL BLDG. AREAS		1955 BLDG. AREAS		% INCREASE
HOT MILL	435,400 SQ.FT.	HOT MILL	629,000 SQ.FT.	44.4 %
COLD MILL	475,900 SQ.FT.	COLD MILL	1,047,500 SQ.FT.	120.0 %
TOTAL	911,300 SQ.FT.	TOTAL	1,676,500 SQ.FT.	84.0 %

Figure 4 shows the growth in the building areas needed for the increase in tonnage.

SERVICE FACILITIES

The increase in capacity at both the hot and cold mills required major additions to the utilities for the plant, principally electric power and water. While the original plant had been built with 25-cycle electric power throughout, in 1950 a new 30,000-kva, 13,800-volt, 60-cycle primary substation was built to supply power to the rebuilt tandem cold reducing mills, annealing furnaces, etc., in the cold mill department. The same substation also supplies current for the additional power load at the hot mill.

The larger furnaces and the faster rolling rates in the hot mill increased water consumption materially, necessitating new distributing mains from the main pumping stations to the strip mill. In the hot mill proper, the mill roll sprays and cooling water used on the mill runout table were divorced from the normal 35-psi service water system and set up on a separate 14,000-gpm, 125-psi system. This system supplies the cooling water for the mill rolls and the metallurgical cooling of the strip between the mills and the coilers.

A third 1200-gpm, 1200-psi hydraulic spray pump was also added, giving the hot mill a total of 3600 gpm of high-pressure water for descaling purposes.

INSTRUMENTATION

In looking backwards at many of the improvements made and the benefits derived from them, particularly in the cold mill, the writer believes that considerable credit for their success must be given to the development of proper instruments and gages and the evolution in the complicated electrical control systems needed for today's higher speed, higher tonnage operations. Without such items as the rotating regulator and magnetic amplifier control, flying micrometers, X-ray and beta-ray gages, tensiometers, etc., some of the speeds used in today's mill equipment would not be practical since the mill operating personnel could not know just what was going on without them. At Lackawanna, a liberal amount of such devices have been used wherever possible in order to give the operators all the visual help possible. In the same connection our operating personnel deserve a lot of credit for their splendid cooperation in accepting many of the newer developments and going through the growing pains of making some of them work.

In the final analysis, what we have been able to accomplish in building around the original 1935 model mills, is to increase the hot mills band capacity from 50,000 to over 200,000 net tons per month, or a 4-time increase. The cold mill department has been increased from 20,000 net tons per month to 150,000 net tons per month, or 7½ times. It is interesting to note that all of these increases and changes have been made with a very minimum of interruption to production during the construction. At the same time, production costs have been kept within limits that are quite comparable with some of the more modern mills, erected at a time when builders were able to take better advantage of the newer developments in the art of rolling strip steel.

DISCUSSION

PRESENTED BY

J. N. IMEL, Superintendent Sheet and Strip Departments, Jones & Laughlin Steel Corp., Pittsburgh Works, Pittsburgh, Pa.

H. E. MULLER, JR., Assistant Superintendent Roll Department, Inland Steel Co., East Chicago, Ind.

T. J. KOENIG, Division Superintendent Rolling Mills, United States Steel Corp., Fairless Works, Fairless Hills, Pa.

CLARENCE R. MITCHELL, Division Superintendent Rolling Mills, Granite City Steel Co., Granite City, Ill.

F. S. ECKHARDT, Chief Engineer, Bethlehem Steel Co., Lackawanna, N. Y.

J. N. Imel: I would like to ask the author if at the present time they have reached their peak of capacity on their 79-in. mill; and if not, can they increase their capacity, by first increasing their heating capacity by a fifth furnace; second, increasing capacity by a larger slab weight which will entail changes in their blooming mills; and third, by increased mill speeds? If these were possible, with the cold mill facilities that they presently have, would they be able to accommodate the increased hot mill capacity?

H. E. Muller: There are, to my knowledge, two other hot strip mills very similar to Lackawanna's mill which are now being considered for major revamping in order to increase productivity.

As pointed out by Mr. Eckhardt the methods of increasing the productivity of a continuous hot strip mill consists of these elementary moves.

1. Increase the heating capacity (a common restriction to production).
2. Increase the coil weight by increasing slab volume or weight.
3. Increase the mill finishing speed.

In considering these moves individually one may encounter difficulties.

1. For example space limitations may deter the addition or enlargement of heating furnaces. Lackawanna's reduction of furnace wall thickness in order to increase the slab length is very interesting. I would like to ask Mr. Eckhardt if any difficulty has been encountered structurally or with refractory life due to this change?
2. The increase of slab volume may be accomplished by furnishing wider and thicker slabs from the blooming mill, and the elimination of broadside passes. If it is desired to eliminate all broadsiding up to the widest bands a universal slabbing mill may be required.

   The thicker slabs require changes in the mill proper. The extra work must be done either in the roughing train or the finishing train. In Lackawanna's case it was necessary to provide additional space between No. 4 and No. 5 so that the additional length could be accommodated on the

delay table. In addition they entered No. 5 with a thicker bar a situation which is inherent in increasing the starting slab thickness. I would like to ask Mr. Eckhardt if they had considered moving No. 5 stand to the delivery end of the mill in order to provide a longer delay table? I also am curious to know whether in his opinion, if this had been done, would the addition of stand No. 11 still be necessary for reduction purposes. I realize that the addition of this stand has undoubtedly made for higher delivery speeds and tends to distribute the work in the finishing train better. However, in view of the fact that other productivity gains may be obtained without adding a seventh stand to the finishing train, that this would be the last step in such a program.

I would also like to ask Mr. Eckhardt several questions on their program.

1. Was the surface of the finished product affected when a heavier piece entered into the finishing train? Since No. 5 mill is actually a roughing mill, was it necessary to provide additional descaling somewhere in the finishing train after No. 5 mill?
2. Why was the horsepower of No. 1 scalebreaker increased from 1000 to 1700 without a change in roll diameter? Is this mill used to take a reduction on the slab?

T. J. Koenig: In the past eight years, most hot strip mills have changed to rotating mandrel type coilers. Mr. Eckhardt mentioned that the 79-in. hot strip mill is operating with the conventional type coilers. Could he tell us why the coilers were not changed to the rotating mandrel type.

Clarence R. Mitchell: I noticed that the slab reheating furnaces were revamped from the refractory recuperators to metallic. I would like to know what advantages were obtained and if the advantages offset the additional expenditure?

As we all know, the metallic recuperators are much more expensive.

When the seventh stand was added to the train, did it help the strip shape or what effect was there? What benefits did you get out of the run-down on your strip? How much did you decrease your decimal thickness?

I have another question here that has been debated among many of the hot strip people as to whether or not one can get a straighter strip out of a continuous mill than out of a semi-continuous mill? Can you give me your opinion on that?

F. S. Eckhardt: In answer to Mr. Imel of J & L as to whether we think we have reached our peak in capacity, the answer is no, we do not. We believe that a fifth furnace will add considerably to the mill's tonnage for certain conditions of orders. We have been talking about it. Someday we will probably have it, but I would say that any further increase is in our opinion going to come from increased slab weight, that is unit weight, more so than anything else.

A mill like ours is very similar to that at J & L—if you multiply it out you will find you are handling some 45,000 pieces a month and it is just a case of the time to handle that many pieces. The further increases that we are looking for, and we believe they are appreciable —will be done by going into heavier slabs, which is going to mean a further change in our roughing mill train.

As far as mill speeds are concerned, it is our opinion that our mill, which is 2,000 fpm, for the kind of orders that we have is adequate. We have no tinplate—we are all primarily heavy gage. We would see no particular advantage in going to anything faster than the 2,000 fpm we have.

Your other question on the cold mill facilities, if we could increase production by rolling more through the hot mill, my answer is yes, we could. The annealing of course is always a problem. That is simplified by adding more furnaces as you need them for production.

As far as we are concerned, our particular limitations we believe would come next in the tandem cold reducing and in the three picklers. We can take quite an increase, I would say in the range of 15,000 to 20,000 tons a month, with our tandem mills and picklers the way they are. For anything beyond that, we would have to look for more tandem cold reducing and more pickling facilities primarily.

In answer to Mr. Muller's question on the refractory construction of the furnace side walls, we experimented with that for a couple of years before we went into full production on it. We took out the brick walls which were made up of 13½ in. of fire brick and 4½ in. of insulation originally, and we have replaced them with rammed material. We have had no trouble from the buckstays. We took one side wall and replaced it entirely for a trial. It was in use for about two and a half years and our refractory man told me recently that as yet that wall is still in very good condition. He did say this, however, that in the soak zone of the furnace, at the point of the greatest temperature, we expect to get about a three-year life out of that particular area. On the balance of the furnace it still looks as good as the day it went in. So we have had no particular trouble in a little over two years.

On your question on the location of the eleventh stand, and whether we thought about moving number five stand down, yes, we did; but actually in our case we found that the space limitation between the roughing mill and finishing mill trains was not as critical as the space between stands two and three and three and four, and until such time as we get to a point that we need more space between the roughing and finishing, we are all right.

I would answer your question this way: If you could do both, if you could move number five stand down and make that number ten, and then put a number eleven on behind that—I would think you would have a better job than we have. There certainly would be no objections to it at all. It would be a good move. We are close, but we get by with the space limitations still being back in the roughing mill.

In answer to your question about a change in the finished sheets' appearance and whether we need any additional descaling, I do not know that I can answer that entirely for you. I am not a metallurgist. I will answer it in this way—that our product is better today than it was before. We did not change our method of

descaling. We did add, and primarily as a standby unit, a third 1200-gpm, 1200-psi, descaling pump, but we did not change our method of descaling. To the best of my knowledge we have no trouble.

I will say this further, we found that in going into the finishing train with a thicker, hotter bar, we had to use a lot more water between the finishing stand and the coilers in order to get the strip temperature down before coiling. I think I noted we are now pumping some 400,000 gphr on the runout table, from a 125 psi water system.

You raised the question about the scalebreaker. We changed that from 1,000 to 1,700-hp motor and still maintain a 20-in. roll. We plan to take very little reduction on the scalebreaker, not over a quarter of an inch. We found the original 1000-hp motor used to kick out from overload. Our slabs come from a blooming mill and occasionally if the slab comes through a little thick, the scalebreaker would kick out. We happened to have a 1700-hp motor and put it on. It has worked considerably better. There was no intent when the motor was changed to think we were going to take more reduction on the scalebreaker. We admit our scalebreaker is not adequate. If we make any subsequent changes to the hot mill to increase its capacity, we obviously would take out the scalebreaker and put in a real two-high mill.

To answer Mr. Koenig's question about the coilers, we have three rebuilt stationary mandrel coilers. At the time we rebuilt ours, shortly after the war, there was some question in our operators' minds about rotating mandrel coilers. Again in the interest of some economy, we were able to take two old coilers and rebuild them by changing the frames and changing the roll carriages so that we could handle a bigger coil. We put the third coiler in of the same design. As of today I do not think that anyone at Lackawanna would disagree with you. We would like rotating mandrel coilers. Someday we will probably have them as part of an increased production program.

Answering Mr. Mitchell's question about the slab furnaces, and why we changed from tile to metallic recuperators, the original tile recuperators had been in service, at the time we changed them, about 15 years. We were faced with the problem that the tile recuperator itself needed rebuilding. We were getting some leaks. There were high pressure drops through the recuperator, which affected the furnace draft and limited the amount of oil that could be fired. At high firing rates we just blew smoke out of the back end of the furnaces.

We used to get an air preheat in the range of about 400 F maximum through the old tile recuperators. We felt that the metallic recuperator was much better in that we would get far less pressure loss in the flue system and also there would be fuel economies from an air preheat of 650 F as compared to 400 F with the old tile construction.

We also eliminated a rather costly maintenance item by eliminating the hot air fan. The metallic recuperator has cold air fans on both sides with the venturi ejection system handling the stack gases and a cold air fan on the combustion air side. We have proven that the metallic recuperator meant about five cents a ton saving in heating costs.

Your question about the seventh stand—what effect it had on the shape of the strip. Again I do not know that I can answer that for you specifically. All I can tell you is this, that our operating people are very well satisfied with the shape of the strip that they are getting from the seven-stand finishing train and it is better than we obtained from the old six-stand train.

Now your question on the mill rundown—how much did we reduce it? I am sorry that I cannot answer that specifically. Again I can only quote. The operators tell me that the rundown is better, but I cannot tell you how much better.

Your last question about a straighter strip off a continuous or semi-continuous mill—I do not believe that I am in a position to answer that one either.

1956

AISE CONVENTION AND EXPOSITION

CLEVELAND PUBLIC AUDITORIUM

CLEVELAND, OHIO

SEPTEMBER 25, 26, 27, 28

HEATING HEAVY SECTIONS—HOW FAST?

By QUENTIN M. BLOOM

Project Engineer, Selas Corp. of America, Philadelphia, Pa.

▲ STEELMAKING consists largely of heating and forming. Perhaps it can be said that a steel plant is an organization of furnaces and mills with skilled operators at their many controls. Great strides have been taken in designing, building and operating our modern high speed mills in all branches of steelmaking, but the desire for better mechanical steel-working tools often causes one to overlook the other phase of steelmaking, the furnace, as an equally important tool. High speed furnaces are just as important as high speed mills. Product quality and production rate is just as dependent on furnaces as it is on mills. Scale loss, the amount of work in the furnace, and the quality of the heated work piece are economic considerations for furnaces as similar considerations are for mills.

Perhaps high speed heating furnaces, conceived to meet the demands of high speed production mills, can contribute to the development of the steelmaker's furnace as an improved tool for his precise requirements. A few recent applications of high speed heating of heavy sections will illustrate their merits as a steelmaker's tool.

Heat treating die blocks, for example, has always been considered a difficult heating operation because they are usually made of inherently crack-sensitive steel. A typical percentage analysis might be:

C	Mn	P	S
0.50/0.60	0.70/1.00	0.04	0.04

Si	Cr	Mo	V
0.25/0.40	0.85/1.15	0.40/0.50	0.06

A generally accepted time cycle has been 20 to 30 hours. These long cycles have been required to be absolutely certain the die block was heated with reasonable uniformity throughout the steel, and by so doing, prevent cracking.

A die block manufacturer, like other steelmakers, had a production "bottle neck" in his heat treating department and turned to high speed heating methods to overcome the problem. A furnace, shown in Figure 1, was placed in among a row of twelve conventional furnaces to heat die blocks for quenching. Die blocks are placed on supporting piers on the furnace car hearth, and, after entering the furnace, are heated between two walls clustered with radiant gas burners. The burners can be seen on the left wall of the single door, car hearth furnace, shown with the door in its raised position.

A single die block, or many smaller blocks can be grouped together to make up the maximum charge size of 24 in. thick, 36 in. high and 20 ft long. Block thicknesses ranging from 8 to 24 in. are handled with ease. In Figure 2 a charge of 15 small die blocks weighing 23,832 lb is shown being removed for quenching from the high speed heating furnace.

In order to determine time cycles, die blocks of various thicknesses were prepared with test thermocouples located at the surface and the center of the block. Figure 3 shows several test time-temperature curves for an 18 in. thick block. The first test, shown in dotted lines, illustrates full penetration of heat through the block in 4¾ hours, when the surface temperature was brought to 1550 F and held until center thermocouple reached this temperature. The second test, shown by the solid lines, illustrated equalization of temperature in the die block in 3¾ hours, a reduction of one hour from the first heat. To shorten the time cycle, the surface was heated to 1650 F for several hours and then reduced to 1550 F. Again the temperature of the die block was the same on surface and center and ready for quenching.

Developments in the science of combustion enable the operator to heat sections at much higher rates than previously believed possible . . . . such rates will find applications in many processes . . . other applications await further knowledge on metallurgical and economical limitations.

Figure 1 — Radiant gas burners, of the nozzle-mixing type, assure uniform fast heating of die blocks in this completely automatic program control furnace. Up to 56,000-lb work loads have been heated for hardening in this furnace.

Figure 2 — A load of 15 die blocks, totaling 23,832-lb in weight, is being removed for quenching after heating in the furnace shown in Figure 1. The work load has been heated in only 3½ hr, compared with 20 to 30-hr cycles for each of the 12 adjoining conventional furnace.

As a result of these thermocouple tests a time-temperature program type of control was applied. A series of time-temperature control cams were cut for various thicknesses of die blocks. These cams regulated the fuel input of the furnace to control the die block temperature. In spite of wide variations of load weights for a like thickness of die blocks, the time-temperature curve is plotted on the temperature control chart with an amazing degree of duplication. Figure 4 illustrates part of the control panel with the furnace superintendent changing one of the time cycle cams.

Die blocks are subject to rigid metallurgical and sonic inspection. In one instance, soon after the furnace was placed into operation, sonic inspection, shown in Figure 5 detected a flaw or crack along one edge of a die block heat treated by the high speed process. Since it was a surface crack it was first believed to be caused by the heating method. Alarm was dispelled when the piece, shown in Figure 6, was chipped out of the die block and proved, by the presence of oxidation in the crack, that this flaw was present before heating. In fact, if a die block is to crack due to fast heating, it appeared this should have caused a greater and more serious defect, and the absence of further cracking proved that high speed heating is safe and practical.

Perhaps one's first reaction is that the furnace must have a large fuel burning capacity. One may also expect that the total fuel consumption is high. If so that is partially correct because the fuel burning capacity is greater than usually found in conventional furnaces. In fact, the fuel capacity is great enough that the furnace has been heated to 2200 F in 3½ min after the burners were lighted and the control valve opened. But in spite of this startling performance, one should look at the facts. The graph shown in Figure 7 shows fuel input, furnace temperature and block temperature for the charge of 15 die blocks shown in Figure 2. The graph indicates that the fuel input reached a rate of 31,000,000 Btu per hr for a brief time in the first hour of operation. However, note how the fuel input dropped off very quickly and became so small that it registered 0 input for over an hour. The total heat input for the entire cycle was only 25,500,000 Btu, in spite of the peak rate of 31,000,000 Btu per hr.

The fuel required for the high speed heating of die blocks is actually less than 80 per cent of the fuel used to heat an equal amount of steel in this plant's conventional furnaces, measured on a monthly basis.

Figure 7 also illustrates the die block surface temperature with its rise to 1640 F and the ultimate equalization at 1550 F. Furnace temperatures for the entire cycle are also shown. The rapid furnace temperature rise, the dropping of the temperature and the ultimate leveling off for holding, all with a full load, effectively

Figure 3 — Effect of two different cycles on heating rate of an 18-in. thick die block. Dotted lines show center of work coming to temperature in 4¾ hr. Solid line curves show time reduced by one hr when surface temperature is increased. Conventional heating cycle takes 20 to 30 hr.

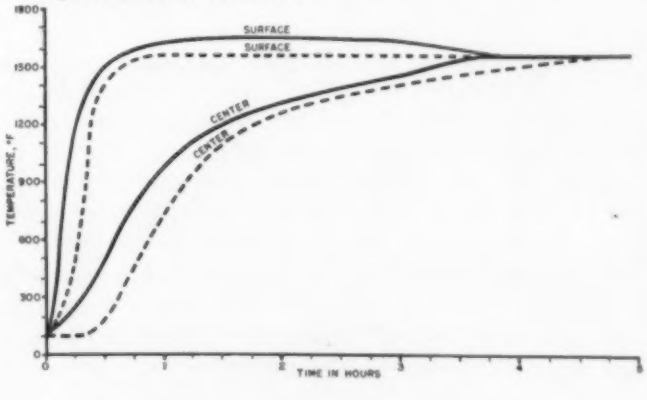


Figure 4 — Proper control cam is inserted in position on control panel. In operation, the cam functions as a remote setting to specify a desired furnace temperature at a particular time.

Figure 5 — Sonic testing assures shipment of sound, quality die blocks.

illustrates the extreme flexibility and controllability of the high speed process.

Because of the very short time cycles, the high speed heating furnace produces four to five times more heated steel than is obtained from the conventional furnaces. Production for the first 9 months of 1955 is estimated to be 12,000,000 lb of heat treated die blocks. One can only conclude that a furnace of the same size as the conventional furnace, but with the ability to produce four to five times more heated steel, at a fuel saving of greater than 20 per cent is truly a modern, high production furnace and rightfully classed as a new improved steelmaker's tool.

Figure 6 — Conclusive evidence of the absence of any crack-forming tendencies of fast heating, when applied uniformly and under controlled conditions, is contained in this chip. The crack, formed in the die block previously, was in no way aggravated by the fast heating cycle.

Another radiant-fired furnace for heating very large die blocks is shown in Figure 8 shortly after being lighted.

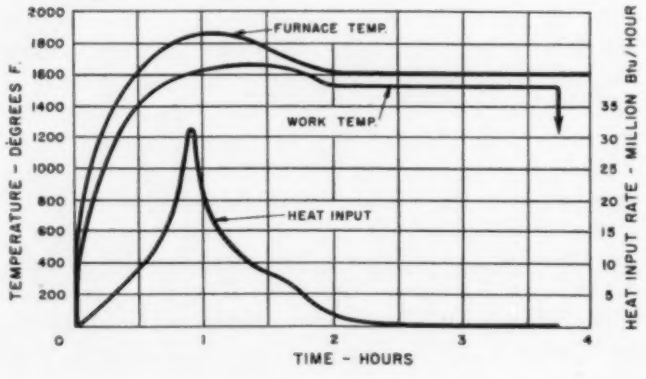
The main difference between this furnace and the one previously described is the operating temperature. Die blocks are fast heated to only 1000 F at a rate of 5 in. per hr, a heating rate approximately five times faster than the 1 in. per hr normally practiced.

Moreover, the size of these blocks ranges up to 10 ft x 24 ft x 3 ft 4 in. weighing 384,000 lb, which is complicated by the fact that the working surfaces of these finished dies are contoured. The achievement of uniform temperature throughout the die, under these circumstances, is an important consideration.

It is evident from the two examples that fast heating is practical for low and intermediate, as well as high temperatures.

Hardening of steel rolls is another interesting application of fast heating. Rolls are also made of critical

Figure 7 — Charts give relation of furnace temperature, work temperature and heat input, in program control heating the 23,832-lb load of die blocks shown in Figure 2.



steels and the analysis used in a recent temperature distribution test was as follows:

C	Mn	Cr	Mo
0.90	0.30/0.40	1.50/1.75	0.30/0.40

The roll used for the test was 14 in. diam by 32 in. face, with a 2½ in. diam internal bore and an estimated weight of 2240 lb.

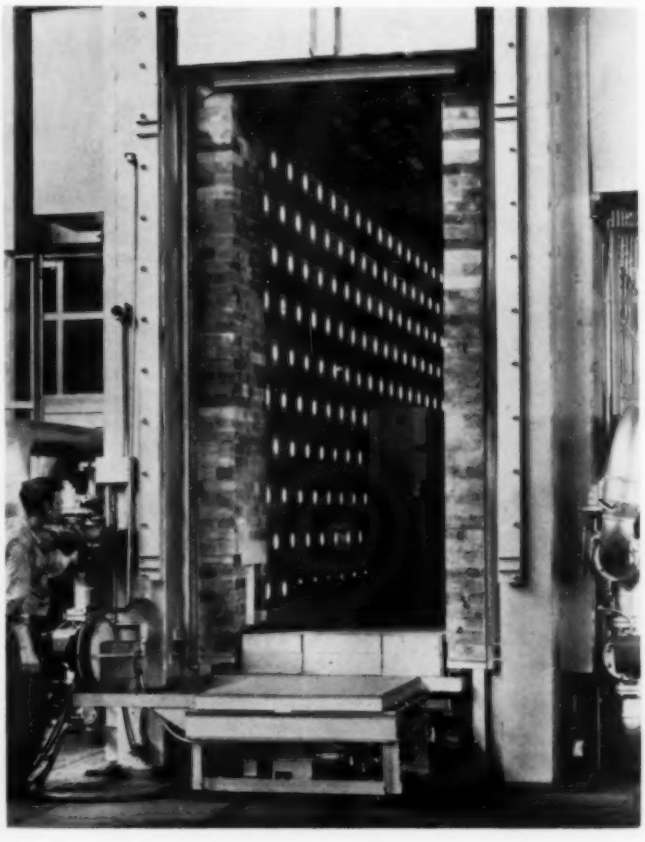
To satisfactorily heat treat this roll the surface must be heated to 1550 F and the bore to 1520 F. Conventional practice requires several stages of heating and takes 18 hr, but fast heating reduces this time by 90 per cent.

Figure 9 shows the temperatures for four thermocouples plotted in respect to time and represents temperatures of the furnace chamber, the roll surface, 1½ in. below the surface and 4½ in. below the surface. The cold roll was placed in a furnace operating at 2450 F at the start of the heating cycle.

Particular points of interest are: (1) the 20 minutes required to bring the roll surface to 1550 F, (2) the 38 minutes to attain 1250 F in the bore, a stage that requires 14 hours in conventional practice, and (3) that the temperature distribution required was obtained in only 95 minutes.

The heating of ingots for rolling has always been an operation that consumes long hours of the steelmaking process and occupies large areas in a plant. Any attempt to shorten the time cycle is immediately faced

Figure 8 — Fast heating is applied to heating finished dies, in preparation for forging aircraft components. Final temperature of 1000 F is achieved at heating rate of 5 in. per hr, five times faster than conventional methods.



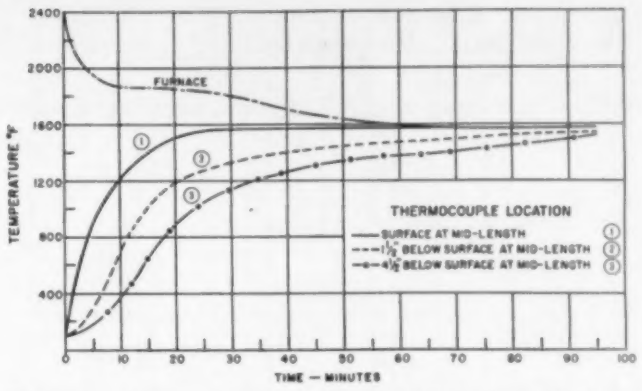


Figure 9 — Heating curves were obtained when placing a steel roll, 14 in. diam x 32 in. face with a 2½-in. diam internal bore, into a gradiation furnace at 2450 F. Desired temperature distribution, of 1550 F at the outside surface and 1520 F at the bore, was achieved in only 95 minutes. Conventional practice takes 20 hr.

with certain physical handicaps. The high speed heating of smaller shapes was largely successful because the heat was applied uniformly all around the workpiece. It is also known by actual thermocouple test that a 5 in. diam billet, lying on a furnace hearth and heated from above, had a 50 F temperature difference between top and bottom surfaces, therefore it would be fruitless to lay a large ingot on its side and expect any degree of uniformity.

To stand a top poured ingot with its characteristic bulge in the bottom, in an upright position, is very desirable for heating. To avoid the "rocking chair" action of the top poured ingot when resting on its bottom, it was decided to support it on a group of pins to permit the bulge to hang below and between the support pins but not contact the hearth in any way. This gives a large section supported in such a manner that heat can be applied all around the ingot thus permitting rapid heating.

At the 1953 AISE Annual Convention, F. O. Hess reported on experimental high speed heating of ingots for rolling. See paper "Heat Processing in Industry—Facts and Figures," 1954 Proceedings AISE. Since then, a full size installation has been made, where ingots approximately 19 x 23 x 78 in. are heated and rolled into blooms for a structural mill. The installation consists of a group of six holes constructed in pairs in three furnace shells, as shown in Figure 10. Note that the holes were designated as 8A, 8B, 8C, 8D, 8E and 8F. Holes A, B, D and E are fired by nozzle mix radiant gas burners patterned in the side wall and radiating the radiant energy uniformly on the ingot. Holes C and F are heated by waste products of combustion and intended to preheat cold ingots with normally wasted products of combustion, after which they would be transferred to the radiant fired holes for finishing. In operation, because of the extreme flexibility of the fired holes, a large number of cold ingots are charged directly into the fired pits.

Figure 11 is a section through a pair of holes in a casing, say holes A and D. Each hole contains three ingots supported in an upright position on pins. The furnace chambers are vented through the lower end walls to a collecting flue gas trench. The covers are

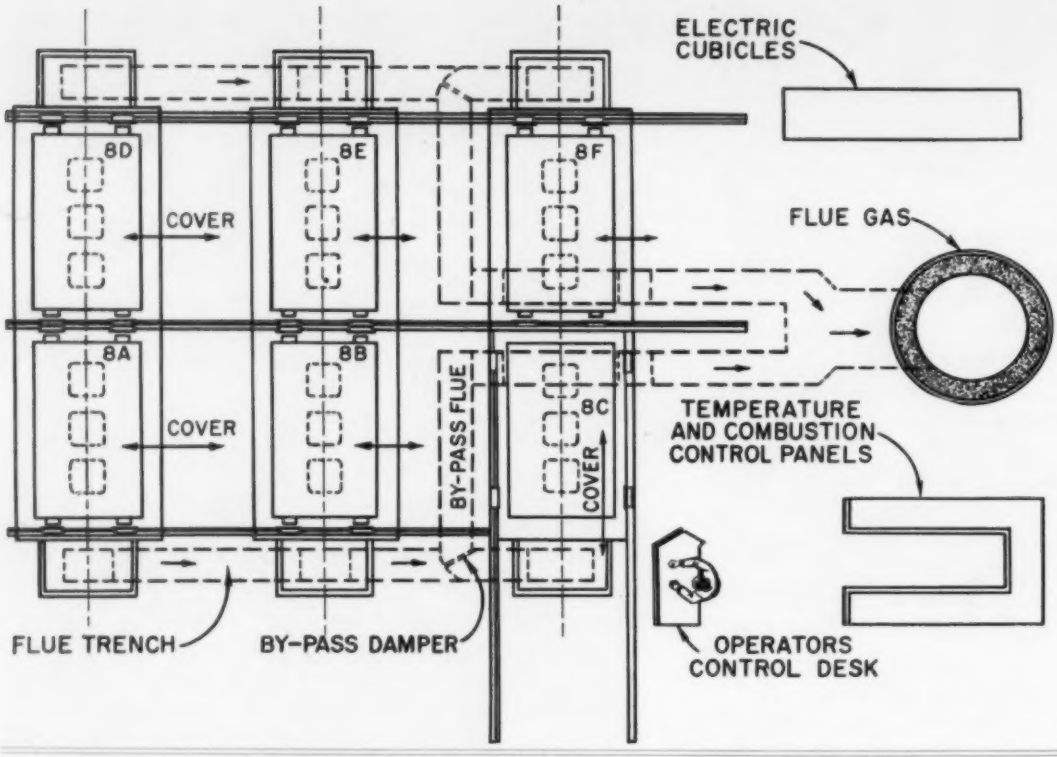


Figure 10 — Installation for fast heating 19 x 23 x 78-in. ingots for rolling. Holes A, B, D and E are fired by radiant gas burners patterned in the side-walls; holes C and F are preheat zones heated by waste products of combustion.

completely mechanized and automatically raise and roll back when directed by the operator. Figure 12 gives further details on the ingot heat processing furnace. Observe the radiant cup shaped burners nozzle mix mounted in the side walls and the ingot standing upright between opposing walls of burners.

The furnaces are equipped with gas-air ratio controls to control combustion, automatic proportioning type pneumatic temperature control and automatic pressure control. Each burnered hole is complete with its own controls and operates as a separate furnace independent of adjacent holes. All furnaces, however, are vented through a common flue gas ejector type of stack. Close examination of this equipment reveals many novel and unusual features, for a good deal of original thinking was necessary to apply high speed heating to ingots.

One operating result has been the unusually clean ingots that have been produced by high speed heating pits. Figure 13 shows one of these ingots being removed from the pit.

The important feature of these novel furnaces is their remarkable ability to rapidly heat ingots for rolling. Ingots are heated in a fraction of the time normally required in the average soaking pit. Heating time usually considered necessary for ingots of this size is calculated by the formula "track time plus 1 hour with a minimum of 2½ hour."

Heating time is dependent on incoming ingot temperatures. Through a concentrated program to determine ingot temperatures at time of charge into heating furnace, a reasonable correlation between "track time" and ingot temperature was found. Using track time as a basis, Figure 14 shows the heating ability of the high speed ingot heating furnaces in direct comparison with general practice. The conventional heating time varies from a minimum time of 2½ for hot ingots to a maximum time of 8 hr for cold ingots and compares with

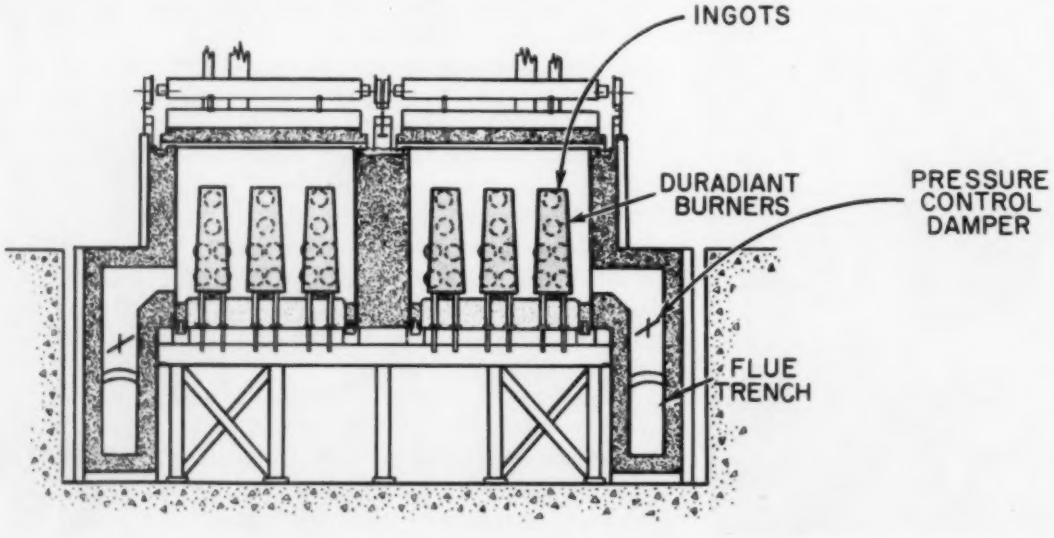


Figure 11 — Section view of holes A and D of Figure 10. Each hole contains three ingots supported in an upright position on pins.

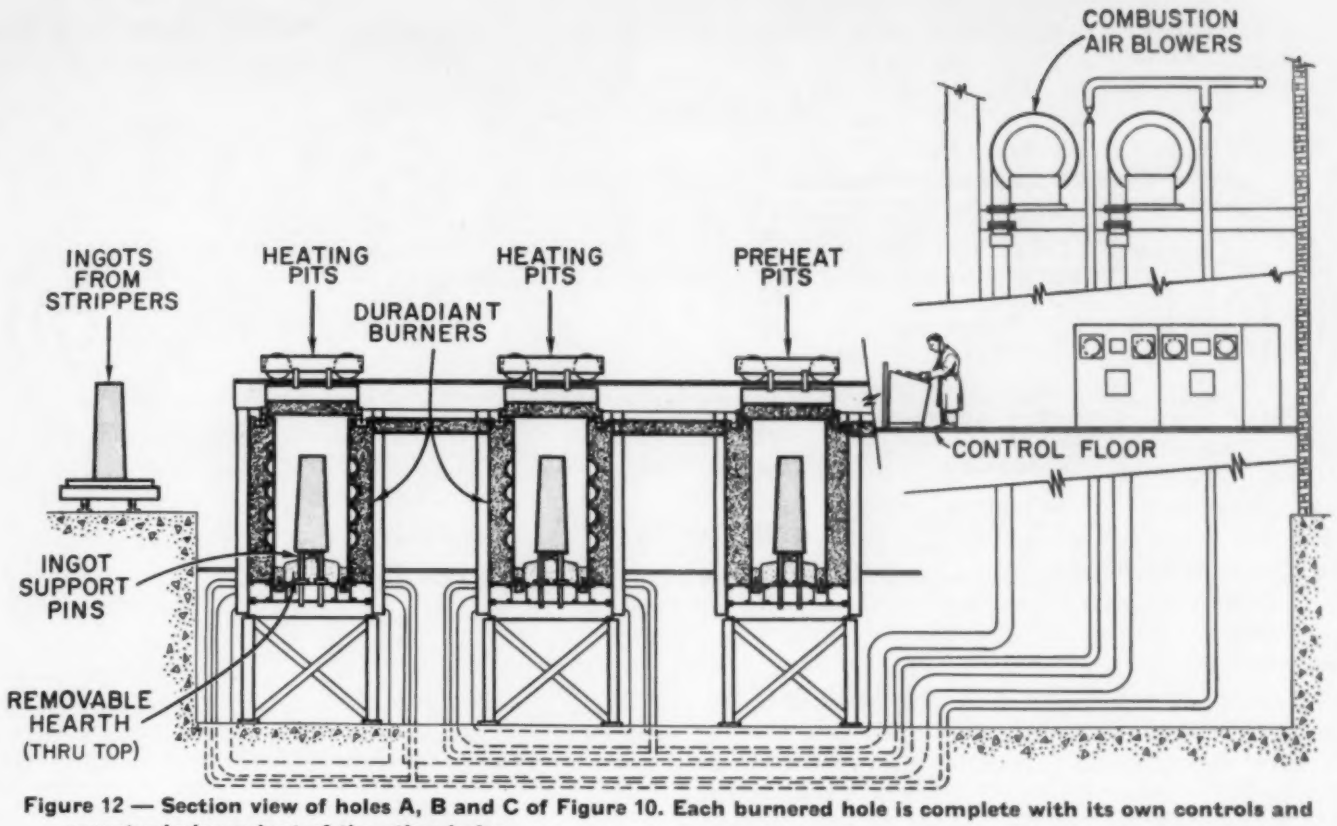


Figure 12 — Section view of holes A, B and C of Figure 10. Each burnered hole is complete with its own controls and operates independent of the other holes.

high speed heating rates of 0.83 hr (50 min) to 2½ hr, respectively.

The drastically reduced heating time for ingots may promote some change in steel mill design. The ability to supply a blooming or slabbing mill shortly after an ingot is charged into a furnace deserves a fresh analysis of ingot processing. For example, consider a plant operating their open-hearths around the clock but blooming ingots only one turn a day. Soaking pit capacity must be sufficient to hold at least 16-hr open-hearth production, or approximately two-thirds of the ingots rolled each day. To provide holding pits and then transfer the ingots to fired finishing pits is another costly and undesirable daily handling of large tonnages, therefore the plant is probably equipped with all pits capable of heating ingots. Short time cycles may permit the steel plant to allow the ingots to become cold between rolling turns and reheat them for rolling in a little over two hr. It is true that the fuel cost per ton for ingot heating from cold may be greater than present practice, but a considerable initial saving of

Figure 13 — Removing an ingot from hole A of Figure 10, for rolling. The drastically reduced heating time, as compared with conventional practice (shown in Figure 14) may stimulate changes in steel mill design.

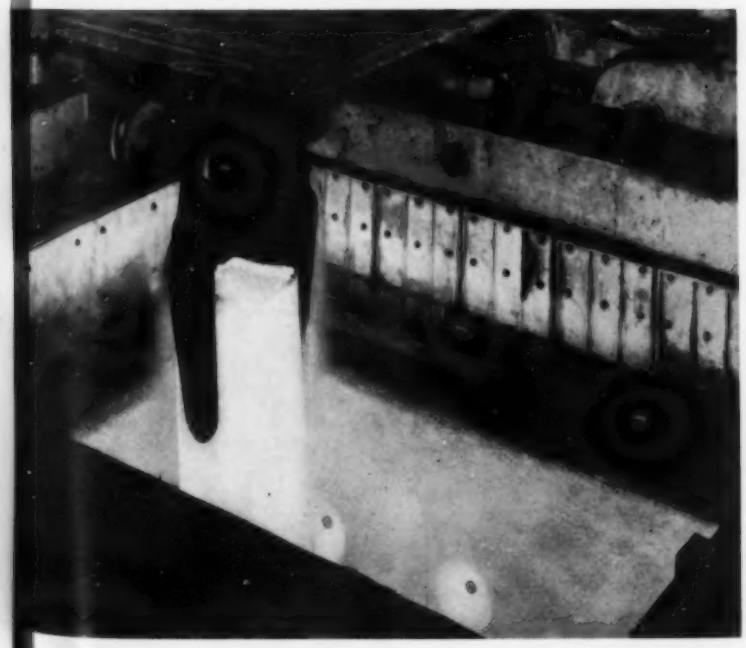
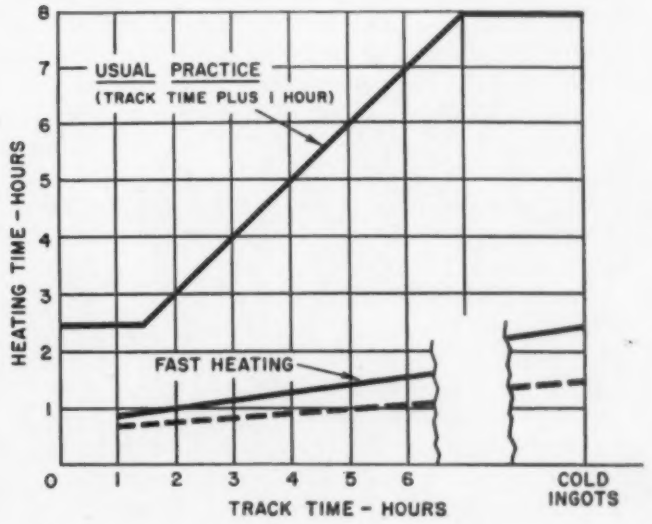


Figure 14 — Heating time vs track time in heating steel ingots to rolling temperature. Note sharp contrast in heating time between gradiation fast heating and conventional practice, for both hot and cold ingots.



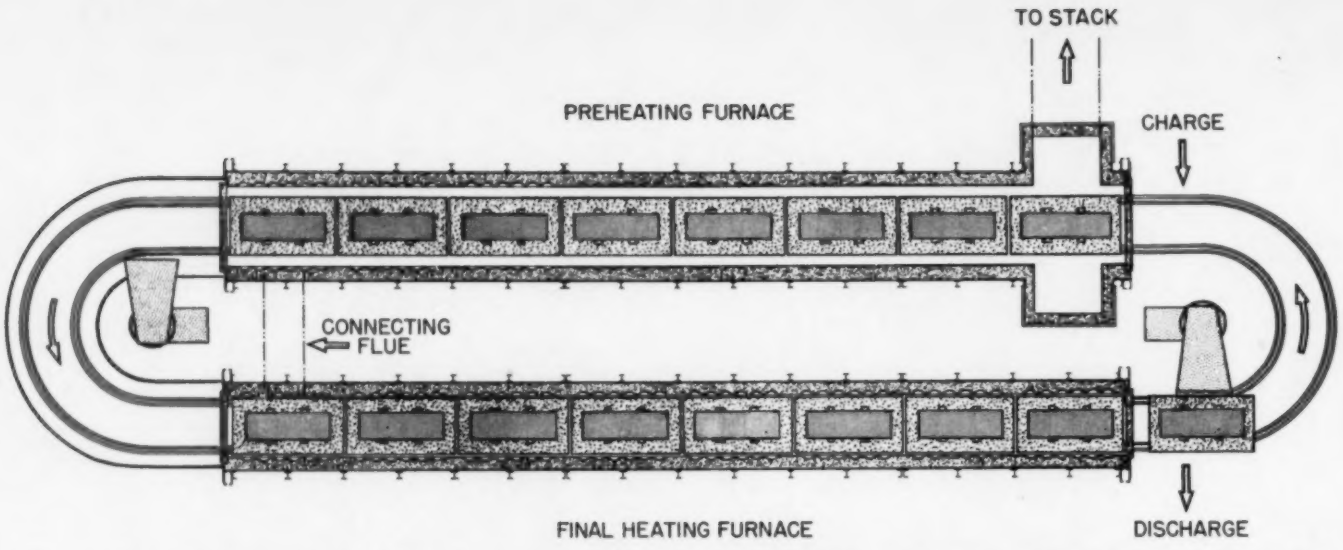


Figure 15 — Continuous ingot heating furnace incorporates high speed heating through use of nozzle-mix radiant burners mounted in the furnace side-walls. Preheat zone (near charging zone) is heated by waste combustion gases.

original capital investment in soaking pits and buildings may more than offset the added fuel cost.

If this approach has appeal, the steel mill designer may consider the handling of ingots in a continuous ingot heating furnace similar to that recently applied to a process for making seamless tubes directly from ingots. In this furnace each ingot will be heated in the same fast time-temperature cycle characteristic of continuous furnaces. Figure 15 illustrates pictorially a continuous ingot heating furnace. This particular furnace was nicknamed "round trip" furnace because of its design wherein a car progresses first through the preheat furnace and is swept around the curved track transfer through the high heat furnace. The car ultimately returns to the initial position—thus the round trip designation.

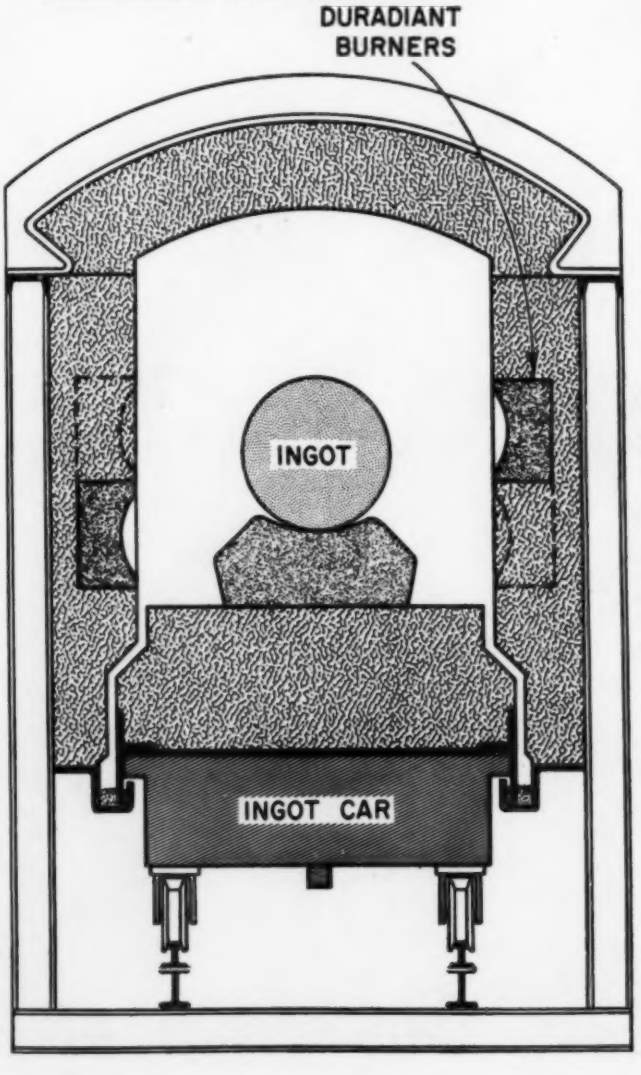
The furnace incorporates high speed heating applied through the use of nozzle-mix radiant burners mounted in the side walls. It also employs counterflow of gases as means of extracting heat from the waste products of combustion by flowing them across the cold ingots at the entrance end of the preheat furnace. This particular furnace is capable of handling ingots ranging from 12 to 23 in. diameter in a total heating time ranging from 55 to 160 min, to an ingot temperature of 2370 F.

Figure 16 is a typical cross-section through the furnace showing the ingot supported on piers so that heat is applied uniformly around the entire ingot from the radiant side wall burners. Figure 17 is taken through the open door at the charging end of the preheat furnace and shows the ingots progressively getting hotter as they travel through the furnace. Figure 18 shows an ingot removed from the final heating furnace ready to be picked up by handling tongs.

The furnace is so flexible that during certain phases of the operation it is used to heat pierced ingots, more correctly called hollow blooms. The furnace is capable of heating as much as 25 tons of large diameter ingots per hour to the unusually high temperatures required in the process.

The terminology "heavy section" is relative to the size of the work-pieces normally handled. To some, the ingot dimensions referred to in this paper may be considered light, particularly if they are handling in-

Figure 16 — Front section view of the final heating furnace shown in Figure 15. Ingots are supported on tiers to permit uniform application of heat.



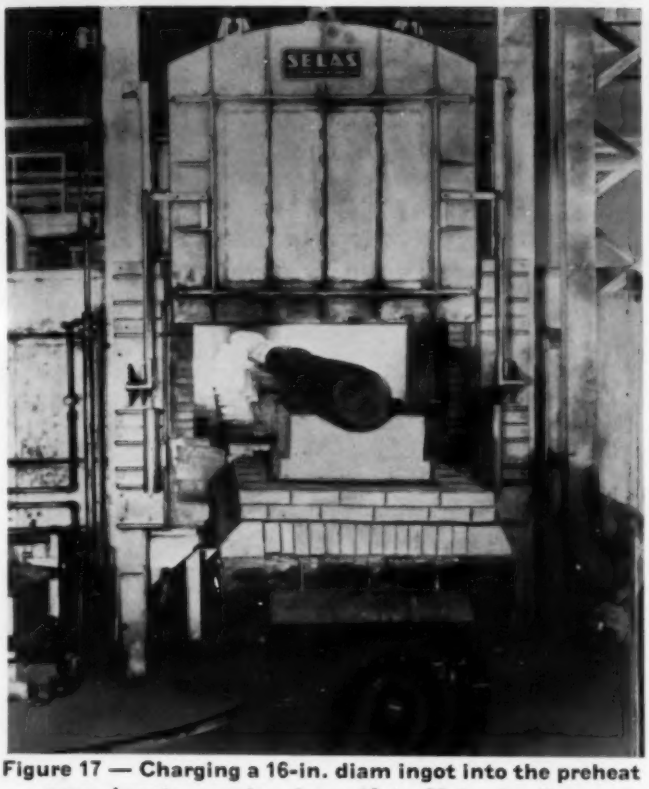


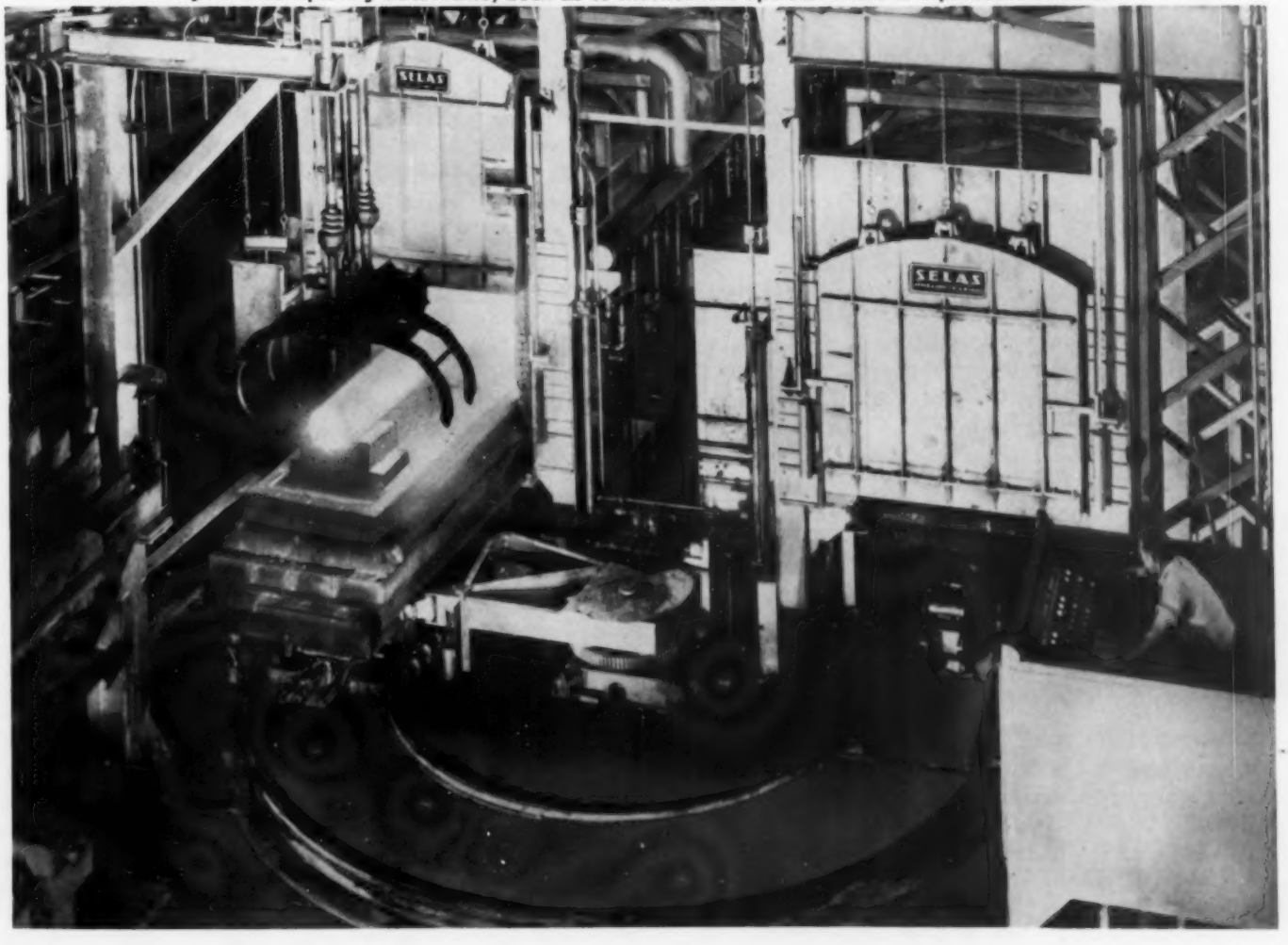
Figure 17 — Charging a 16-in. diam ingot into the preheat zone. Ingots, ranging from 12 to 23 in. in diam, are heated to 2370 F, in the "round-trip" installation, in 55 to 160 min total time, respectively.

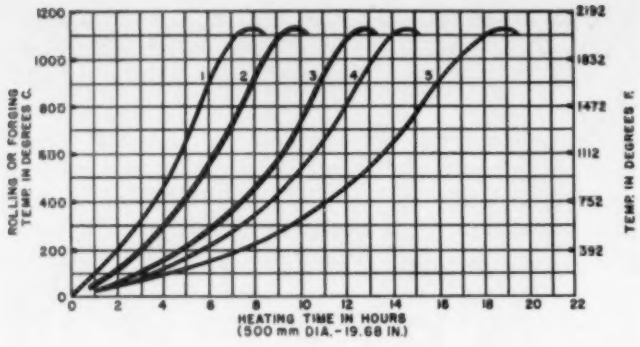
gots for heavy large forgings, etc. To others these sections may be considered heavy because their ingots are normally small for special high carbon steel or alloy products.

This is similar to the strip mill where what is considered heavy section, is being heated to annealing temperatures in a combination annealing-galvanizing line. Actually, 14-gage material is heated in 28 sec to 1300 F and then cooled to galvanizing bath temperatures. The 14-gage material is heavy compared to the tin plate mill where 0.0067 in. tin plate is being processed to 1300 F in slightly over two sec and then cooled before rewinding. These very short time cycles make possible direct open firing of bright steel in a single heating pass annealing or annealing-galvanizing line, and avoid the necessity of handling hard or half hard strip over any furnace rolls. Just as 14-gage is a heavy section to the tin plate man, the 7800-lb ingots are heavy sections when compared to normal steel mill operations.

This paper was entitled "Heating Heavy Sections—How Fast?" because the possible speed of heating has not been fully explored. For example, Figure 19 gives a recommended heating time for various steel compositions and was described in detail in an article appearing in May 21, 1953 issue of Stahl und Eisen magazine. This article is cited as a reference because it represents much of our generally accepted steel mill heating prac-

Figure 18 — Removing an ingot for piercing, after discharging from the final heating zone of the "round-trip" unit. The entire cycle is completely automatic, both as to mechanical operation and temperature control.





COMPOSITION IN %	GROUP NO. 1	2			3			4			5		
C	PURE IRON 99.95% Fe.	.23	.43	.31	.32	.32	.34	.13	.27	.71	.08	1.22	.46
Si		.11	.20	.20	.18	.25	.27	.17	.18	—	.68	.22	1.3
Mn		.63	.69	.69	.55	.55	.55	.25	.28	.25	.37	13.	1.2
Cr		—	—	.09	.17	.71	.78	13.	13.7	4.3	19.1	—	15.2
Ni		—	—	—	3.5	3.4	3.5	.14	.20	—	8.1	—	26.9
Mo		—	—	—	—	—	.39	—	—	—	—	—	—
W		—	—	—	—	—	—	—	.25	18.4	.60	—	2.8

Figure 19—Heating curves for various groups of steels with section size of 500 mm (19.68 in.) in diam. Ingot steels referred to in present paper are related to curve 2; die block and roll steels are covered by curve 3.

tice. This particular chart set a maximum heating rate for the various sized ingots based on that author's experience in his forging shop.

We can relate the steels referred to in our work to the analyses given in the Stahl und Eisen article as follows: the die block and roll steel analyses can be classified as coming under Group 3 (at bottom of Figure 19), while the ingot steel might be considered under Group 2.

By comparing the long time cycles illustrated in Figure 19 those presented in this paper one notes a considerable reduction.

Again one can say "Heating Heavy Sections—How Fast?", for actually the heating t'me given in Figure 14 has been exceeded in special runs of the production ingot heating installation or the previous experimental equipment. The dotted line of Figure 14 illustrates heating times varying from 40 to 91 min. There is reason to believe that these times can be further decreased as far as the steel is concerned, because we have not yet found the limit of the heat receiving ability of steel. Present limits lie in the mechanism to transfer the heat to the steel and to control it. Actually, one can apply heat faster than one can accurately detect the steel temperature, and considerable work will be required to further perfect temperature detection means before one can heat faster on a practical basis.

The applications described in this paper have been in production for some time, are practical and safe. They are truly an improved furnace tool for the steel worker's needs, enabling him to match the high speed requirements and standards required by our modern mills. Time cycles have been drastically reduced but have not reached the still shorter time that is in the foreseeable future.

DISCUSSION

PRESENTED BY

C. C. HILL, JR., Assistant Chairman, Operating Committee, United States Steel Corp., Pittsburgh, Pa.

FRED BLOOM, President, Bloom Engineering Co., Pittsburgh, Pa.

QUENTIN M. BLOOM, Project Engineer, Selas Corp. of America, Philadelphia, Pa.

GEORGE CAMPBELL, Assistant Fuel Engineer, Bethlehem Steel Co., Sparrows Point, Baltimore, Md.

C. C. Hill, Jr.: The author has presented a most interesting group of brief reports outlining the results, in terms of heating time, which have been obtained in the industrial operation of several types of heating facilities developed and installed by his company to serve particular requirements.

These heating times are so short in comparison with the times customarily in use for the same purposes, that they inspire the thought, first, of the desirability of re-examining the more prevalent ideas of the maximum heating rate to which each steel product may prudently be subjected. Perhaps this would lead to a better utilization of the existing conventional heating facilities, even though they do not employ the same method of firing.

The second thought is, of course, the question: What seems likely to be the most profitable use which can be made of this type of firing? The subject of the paper is essentially the speed of heating rather than the economy of heating. The information presented is applicable to this broader question only with reference to those particular elements of heating expense which are related directly to the time factor, and to the amount of investment in heating facilities as a consequence of the effect of the heating time on the productive capacity of the heating installation. The sum of these two kinds of expense represents, however, a substantial portion of the total expense for owning and operating heating facilities. It can serve as a guide to indicate those operations or facilities which warrant further exploration.

This paper should stimulate some inquiring thinking on the general subject of heating as applied to individual existing or prospective installations.

Fred S. Bloom: I am thoroughly in agreement that one of the drawbacks to a great many of our fast heating processes is due to the fact that we cannot measure product temperature accurately, and for batch operations, this is of serious importance.

The author gives the impression that his examples are fast heating, so much so that they are not approached by any existing process in the steel industry. This is not true. For example, we have a number of furnaces throughout the steel industry heating pipe skelp in a furnace that is called the continuous weld skelp heating furnace for the manufacture of butt-weld pipe. Skelp, in a continuous strand of flat steel, is pulled

through a long heating furnace. The material is heated from two sides and is elevated off the hearth of the furnace so that it forms a series of catenaries. In this furnace, the heat transfer is much higher than any other process.

The method of operating this furnace is to maintain it at a high furnace temperature, on the verge of melting the furnace brickwork, and average heat transfer rates in excess of 100,000 Btu per square foot of exposed steel per hour are obtained. Our experience in operating this furnace indicates that product temperature can be controlled by varying the speed of the strip through the furnace.

If an instrument could be developed to measure product temperature accurately, the continuous weld heating furnace could be improved. However, as previously mentioned, since we cannot measure product temperature with an instrument, the operator adjusts the speed of the mill and product through the furnace by eye so that maximum heat transfer and maximum tonnage is obtained. The faster the furnace heats the material, the faster the material is withdrawn so we obtain a very satisfactory operation and very fast heating.

In the author's description of fast heating of die blocks, he does not set up the limitations which I believe must be in the process; namely:

1. Must die blocks in a charge be of approximately the same thickness?
2. How much can the variation in thickness of the die block be in a single charge?
3. In making the comparison between the time roughly stated to be 30 hours and the new process of 4½ hours, is the charge on the 30-hour cycle based on uniform thickness of die blocks or non-uniform thickness of die blocks? It is a much different problem to heat material of varying thickness in a car type annealing furnace than it is to heat a product of uniform thickness.

The author shows a process of heating die blocks of uniform thickness, and indicates a method of heat treatment by which he overheats the surface in order to get a fast temperature rise of the center. I would leave to the metallurgists the question of whether this is a dangerous practice. I ask the author with what degree of accuracy the surface temperature is measured, and can this be accurately duplicated? If heating the surface to 100 F over finishing temperature does not hurt the die block, is it not possible to go 200 F over finishing temperature or to a surface temperature of 1750 F which would still further reduce the time required for the center temperature to reach finishing temperature? I would like to ask the author if he has explored the surface temperature of the die block in the region of the corner surface, particularly top corner which is exposed to furnace brickwork radiation?

It is my belief, due to tests accurately made on material of this size, that the corner surface temperature will exceed the main body surface temperature by at least 200 F. In other words, if the surface temperature of the main body of the die block is 1650 F, then the corner surface temperature will be as high as 1850 F. If the surface temperature of a high quality piece of steel can be allowed to overshoot the quenching temperature as long as uniformity of temperature is obtained before quenching, then the author has made a very impotrant contribution to the method of heat treating steel. I trust our metallurgists can agree with this approach to the heat treating problem.

To go back to the author's original title—namely, "Heating Heavy Sections—How Fast?"—I am questioning the inference of this title. The method of heating die block, as explained by the author, is extremely fast for die block heating compared to all previous methods, but from the heat transfer standpoint, the process is slow. In other words, the heat transfer to the surface is under 30,000 Btu per square foot per hour of exposed steel surface.

The author presents a new concept in the design of an ingot heating soaking pit. The design is such that uniform pit temperature surrounds at least two sides of the ingot. The method of burner and fuel application is ideal for obtaining uniform pit temperature and the elimination of any hot spots. This soaking pit idea is a combustion engineer's dream, but as so many realize, it is difficult to find sufficient room in the average steel mill to make an arrangement of this type feasible. Space required for the heating of three ingots can hardly be justified in a large tonnage steel plant. Combustion engineers for years have complained that poor heating in soaking pits is due to crowding the pits with more steel than they can accommodate.

However, the concept of a soaking pit arrangement must be fully understood to be appreciated. The soaking pits form a transition point between a batch manufacturing operation such as the open hearth department and a continuous rolling operation such as the primary mill. In between these two operations exists the soaking pits. They are a storage yard such as the name implies for holding the ingots which in some cases are at high enough temperature to require no heating. They need to be equalized. In other cases, the center of the ingot is solid and the ingot must be elevated in temperature 400 F to 500 F and the center-surface temperature equalized. In other cases, cold steel must be heated from the bank, but in all cases, enough hot ingots must be ready to operate the primary mill.

Again, the primary mill may break down due to mechanical failure, and space must be available for the storing of hot ingots coming from the open hearth furnace. In other cases, which happen all too frequently, two and sometimes three heats of steel may come from the open hearth department at one time so the soaking pits form a storage yard where ingots must be available at all times for the mill and empty space must be available for the parking of hot ingots from the open hearth. The proper operation of the soaking pits is an important scheduling job.

Studies of soaking pit operation indicate that the average heating job can be done in 2½ to 3 hours, but the actual turnover of a soaking pit hole, taking into account delays of holding steel when ready, pits empty waiting for steel, drawing, and charging make the cycle once in 8 hours. Therefore, it seems a waste of effort to attempt to reduce the heating time from 2½ hours

to 1½ hours by better and more expensive soaking pit design, because the other factors in the operation as mentioned above make it uneconomical. I believe the entire industry has come to this realization and consider the factor of tonnage which can be put under cover to be more important than speed of heating. The author's suggestion that we let all the steel become cold and then set up a continuous heating process may fit some small steel plant operations such as the steel plants who use a bottom pour ingot casting practice.

The author's exposition which indicates that large sections can be heated faster than some engineers and metallurgists believe is a worthwhile contribution to the field of heat transfer, and I believe he should be commended for this approach to the problem. Whether it fits the practical application as regards to a soaking pit or an annealing operation depends upon the economics of the system. At least our author has rightly proven that the ideas of some engineers are much too conservative.

Quentin M. Bloom: Mr. Hill, in his decision, reflects the progressive thinking that has made the steel industry the great productive force it is. He refers to the short time cycles of the ingot heating installation as a stimulant for the re-examination of the generally accepted heating rates of steel. He further proposes, as another consideration of fast heating of ingots, that an analysis be made to determine the most profitable use which can be made of this method of heating. It is an objective analysis, such as this, that will show the importance of fast heating applied to ingot heating and processing.

We cannot and do not hope to directly replace the conventional soaking—and storage—pits as suggested by Fred Bloom without modifying some of the current ideas of processing ingots, no more than we expect to replace an antiquated mill with a modern, high speed mill without making other changes to integrate its potential productivity. I believe the analytic remarks made by Mr. Hill answer to a large degree the discussion by Fred Bloom concerning the acceptability of high speed heating of ingots.

There are a number of points with which Fred Bloom disagrees including the title of the paper. But if we examine his remarks closely, I do not think the area of disagreement is very large. Fast heating of skelp in a butt weld furnace is fully recognized for the contribution it has made in pipe manufacturing. This is only a matter of historical interest, however, for I do not believe any of us would attempt to compare the heating of thin skelp as similar to the heating of heavy ingots, or the continuous furnace synonymous with the batch furnace applied for ingot and die block heating.

The shortcomings in measuring product temperatures were referred to in my paper but I must disagree with Fred Bloom that this is a drawback exclusive to many of our fast heating processes. Actually, this is a drawback to all heating operations, fast and slow, but is shown up to a larger degree in the former, because of the greater possibility of precise control and rapid response in many fast heating processes.

The several other questions that Fred Bloom raised I would like to answer.

1. The die blocks for a charge can vary 2 to 3 in. in thickness. The furnace processes blocks 8 to 24 in. thick.
2. The comparison of time between the previous 30-hour time cycle and the 3¾ hour cycle of fast heating may or may not be based on loads of uniform thickness. It is more important that the new furnace with fast heating has produced 4 to 5 times the tonnage of die blocks than produced in conventional furnaces of the same size—month after month.
3. No visual, optical or metallurgical examination of the die blocks showed overheating of the corners.
4. Under this heating condition, the resulting die blocks are acceptable to the customer, his metallurgists and the ultimate user. So far we do not know the effect of overheating the die block surface by 200 F, but further development work might prove this possible also. We do not know the limit but we do admit that somewhere there is a limit. That limit is the challenge of this paper.

F. C. McGough: I think there should be a differentiation made between a heating or heat treating process and an ingot heating process. I hope that some day we can arrive at fast heating as that described, but it should be pointed out, there are other factors involved. For example, the effect on soaking pits. I, first of all, cannot see how you can have such a heating process without some abrasion, for example. The second thing is it would be nice to run a blooming mill on one turn, taking the ingots off the car and bringing them in, but I think the remark I heard a very well-qualified designer make one time applies. No matter how you design a mold to overcome faulty defects on bloom mills which are carried through strip mills, all the way to the finished product, there is no design can equal what can be done in track time. If you take a standard steel practice, you would then have a sintering when it is cold and the high speed heating would cause damaged corners and pick up scorching or other defects.

The last point I would like to make is that besides the reservoir and the over-all economy as far as fuel is concerned, is the maintenance cost on soaking pits. It would be better in my mind to have possibly the temperatures at greater levels and a greater reservoir, and considering the cost of man-hours at a minimum these days, you are better off to try to maintain pits that have numerous ports inside of them at very high temperatures.

Quentin M. Bloom: Mr. McGough has raised several interesting points on which I would like to comment. The suggestion in the paper that when a blooming mill is operating on a one-term basis per day and the open hearths on a three-term basis, of course would not apply to many of our steel mills, but there are some mills, however, and I know of one considered a most modern mill, that is blooming on a one-term basis.

The combustion system applied to the fast heating pits is considerably different than the burners and combustion system applied to conventional soaking

pits. In fast heating, ingots are heated largely by radiation and the radiant burners do not produce the strong convection currents that would normally wipe around and overheat corners. Actually, the corners of an incoming ingot are colder than the center surfaces and require a greater temperature rise or heat recovery than the body of the ingot.

The installation described is somewhat of an experimental production job. We realized that the normal refractories used in conventional soaking pits might not be applicable to a short cycle operation of the fast heating pits, so the fast heating pits were lined with a number of different refractory linings to compare their service life and maintenance. We are gradually accumulating comparative information and I think we will have a fairly conclusive answer in a short time. Not always are we fortunate enough to be able to make comparison of various refractory linings under identical service conditions and this opportunity will certainly help us apply refractories with low maintenance expense. Fuel economy was purposely not mentioned in my paper. This particular mill operates a blooming mill two terms per day with four hours between each term. Actually, the fast heating pits are shut down twice a day. There are also a large number of cold ingots going into the fast heating pits because of their flexibility and rapid heating of cold ingots, which directly affect the fuel economy. We have made sufficient spot checks and analysis to believe that as this process is further developed, the fuel rate will be comparable with that normally found in other ingot heating processes.

George Campbell: With the higher operating rates demanded of our steel mills today, it follows that heating must be faster and rates better than considered possible just a few years ago.

Mr. Bloom's company has pioneered in the application of direct gas fired furnaces with high radiant heat energy release. With this type burner it is possible to anneal sheet and tin plate coils continuously at 1300 F at a speed sufficiently fast for the strip to leave the furnace perfectly bright and free of oxidation.

We are now annealing 14-gage, 48-in. wide sheet strip in a direct gas-fired, single-pass furnace approximately 25 ft long in 30 seconds, and 30-gage strip in 10 seconds.

Another application of radiant panel type furnaces, is the reflow of electroplated tin plate. Here in a single pass, approximately 30 ft overall, the plated strip is heated to 460 F in less than 2 seconds, for reflow or brightening of tin plate.

With this same type furnace we plan on annealing tin plate gages in about 2½ seconds retention time within the furnace.

I would again like to point out that all of these applications are single pass furnaces. There are other continuous sheet and tin plate lines that operate at faster speeds, in fpm, however, furnaces on these lines are of the multiple pass design with retention time of one to three minutes. Furnaces of this type do an excellent job, but capital investment and floor space required is much greater than the single pass high radiant direct-fired type.

Mr. Bloom's paper could more properly be called "Heating Steel, How Fast?" Certainly great strides have been made in the past few years and what the future holds for higher rates, will be directly proportional to the ingenuity and engineering ability of the furnace and burner designers.

From what we have learned to date, at the operating level, steel in its various manufacturing stages, can be heated at rates much faster than was considered good practice a few years ago.

One question: The high heat release burners discussed in this paper are all coke oven or natural-gas fired. Has Mr. Bloom done any work on high heat release heavy fuel oil-fired burners? What I have particularly in mind is hot strip mill slab heating furnaces, which are predominantly oil-fired. Here is a big field for both better and faster heating. Has he done any work along these lines?

Quentin M. Bloom: We certainly appreciate the comments of George Campbell briefly outlining some of the fast heating applications on thin sections. In response to his question, we have not, to date, applied heavy fuel oil to any heavy slab heating or similar production jobs. We have done some slab heating using gas as a fuel, and, if I recall correctly, 3½-in. thick stainless steel slabs were heated to 2200 F for rolling, in about 20 minutes by fast heating methods. Much work remains to modernize slab heating techniques and equipment.

There is a demand for copies of the following Yearly Proceedings:

1936 1937 1938

1940 1952

If your copies are not in use please get in touch with us.

ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

By K. S. KUKA, Assistant Chief Engineer (Electrical), Tata Iron & Steel Co., Ltd., Jamshedpur, India

SHORT CIRCUIT PROTECTION of Low Voltage Motors and Starters

▲ IN modern steel plants where heavy power is concentrated within a relatively small area, the problem of protection of electric motors and starters against electrical short circuits, particularly in low voltage network, assumes greater importance. Failure to clear a short-circuit on a sub-branch circuit can be associated with chances of production losses and personnel dangers consequent on the damage of low voltage equipment.

The protection of a motor against heavy overloads or protection of a motor, its starter and the branch circuit against short-circuits is basically the same problem. The whole circuit is heated at a rate which is a function of the magnitude of current flowing and the time for which the current flows. The circuit must be interrupted before the motor winding or any part of its branch circuit exceeds a predetermined safe maximum temperature.

To provide the most discriminating protection it is therefore necessary to determine the magnitude of the available short-circuit current, the heating characteristics of the motor and its control and the type of short-circuit protection applied.

High tension distribution systems of modern steel plants are designed such that the maximum short-circuit power is limited to be within 500 mva. At 6900 volts, 500 mva short-circuit power is a huge concentration of power, and efforts should be made to subdivide the system in such a way that under normal operating conditions, the short-power available at substation bus bars remains within 250 to 300 mva.

On the low tension 440-volt system, when two 1000-kva transformer stations are paralleled, it is possible to get 36 mva short-circuit power at the main bus bars, when the transformers are provided with about 5 per cent impedance. With such a system layout, it thus becomes necessary to provide 75,000-amp interrupting rating breakers, which would make the 440-volt distribution very costly. It should therefore be appreciated that more attention is necessary in planning low voltage systems in integrated steel plants from the viewpoint of economy and safety.

This paper discusses the fundamental aspects of the short-circuit currents, and the behavior of various equipments under short-circuit faults, in planning the low voltage systems of any large industrial plants.

. . . . careful planning of the low voltage power supply in modern steel mills is fully as important as planning the high tension distribution from the standpoint of minimizing system short-circuit power . . . . modern load center unit substations properly located will reduce transformer size . . . . load centers should be kept small enough so standard 25,000-amp interrupting rating breakers can be used on outgoing feeders and feeder breakers should be limited to a maximum of 50,000 amp . . . . the fuse gives best protection for motors and starters below 100 amp . . . .

The aspects discussed are as follows:

1. Calculation of the short-circuit currents on the low voltage system.
2. Short-time heating characteristics of a-c three-phase induction motors and the determination of the tripping characteristics of overload and short-circuit protective devices.
3. Behavior of small size motor starters provided with heater-type overload relays on short-circuits.
4. The extent to which small motor starters up to 50 hp at 440 volts require protection against short-circuits.
5. Comparison of the ability of circuit breakers and fuses in protecting the equipment against short-circuits.

CALCULATION OF SHORT-CIRCUIT CURRENTS

In case of low voltage systems, every part of the system has a share in the elimination of the short-circuit currents. It is therefore necessary to estimate

the effects of all the items of the circuit, including circuit-breakers, current transformers, short lengths of large-sized conductors, bus-bars and their configuration, and the motor starters.

To arrive at the maximum possible short-circuit current, the assumptions are made as follows:

1. A solid copper-to-copper short-circuit exists between all the phases at the point of fault.
2. Power available behind the fault is considered infinite, i.e. the primary voltage at the sub-station terminals is presumed to be steady even in case of the severest short-circuit on the low voltage side. This will generally be the case with steel plants primary network, where 300 to 500 mva short-circuit power is easily available.
3. The secondary short-circuit fault current is independent of the time after the first few half-cycles.
4. Current is measured in instantaneous symmetrical rms values. The momentary rms value of short-circuit current to determine the circuit-breaker rating will be 1.25 times the symmetrical rms value. The instantaneous peak value of the current will be about 1.7 times the symmetrical rms value.

The equation for short-circuit current calculation is:

$$I_k = \frac{E}{\sqrt{3}\ Z}$$

where Z = impedance of the short-circuit-loop per phase
$= \sqrt{R^2 + X^2}$

and E = line to line voltage on the secondary side.

R = total resistance in ohms per phase of the fault-circuit.

X = total reactance in ohms per phase of the fault-circuit.

I_k = short-circuit current in amperes.

To determine the total impedance Z, it is necessary to consider resistance and reactance values of each part of the short-circuit-loop separately. For the computation of the total impedance, the system is divided into the separate groups as follows:

1. High tension power supply system.
2. Power transformers at low voltage supply sub-station.
3. Circuit-breakers.
4. Current-transformers.
5. Cables, overhead-lines, bus-bars, etc.
6. Motor-starters.

1. *High tension power supply system*—It is not always necessary to determine the exact reactance value of the high tension power supply system, as it forms a very small part of the total low voltage reactance. The error due to this limitation is usually negligible for all practical purposes. It can however be ascertained whenever possible, from the interrupting rating of the incoming high tension circuit-breaker, from the following equation:

$$\text{Reactance in ohms} = \frac{E^2}{\text{kva interrupting rating}} \times \frac{1}{1000}$$

where E = secondary line-voltage.

2. *Power transformers*—Distribution transformers are designed on a certain percentage reactance basis, the reactance being kept low whenever good voltage regulation and higher efficiency are desired. The ohmic value of the transformer reactance can be calculated from the following equation:

$$\text{Reactance "X"} = \frac{E}{\sqrt{3}\ I} \times \frac{\text{Per cent reactance}}{100}$$

$$= \frac{(kv)^2}{kva} \times \text{Per cent reactance} \times 10$$

where kva = full-load transformer rating in kilovolt-amperes.

I = full-load transformer current in amperes.

kv = line voltage on the secondary side in kilovolts.

E = line voltage on the secondary side in volts.

The per cent reactance is given by the manufacturer and is stamped on the name-plate of the transformer.

3. *Circuit-breakers*—The reactance of a circuit-breaker is almost entirely in its trip-coils. Values for the same size of breakers will vary considerably and it is difficult to get a common value. For practical purposes, for circuit-breakers where series-current trip-coils are provided, the following equation can be employed:

$$X \text{ (in ohms)} = \frac{1}{10^{\left(2 + \frac{A}{500}\right)}}$$

where A = ampere rating of the breaker.

The calculated values for the circuit-breaker reactances are given in Table I. The resistance of the breaker will be mostly the contact resistance and can be neglected.

TABLE I

Inductive Reactance of Air Circuit Breakers at 60 Cycles

Amp	Reactance in ohms
20	0.020
35	0.007
50	0.003
70	0.002
100	0.0009
150	0.0004
200	0.0003
250	0.0003
300	0.0002
350	0.0001

4. *Current-transformers*—The current-transformers, especially of low ratios, play an important part in a reactance diagram. The burden of the current-transformer is also important and should be determined for each transformer in the circuit. The following equation would give the impedance value of a current-transformer:

$$Z_{ct} = \frac{42.5 + B}{I^2_p}$$

where B = secondary burden in volt-amperes.

I_p = primary current rating.

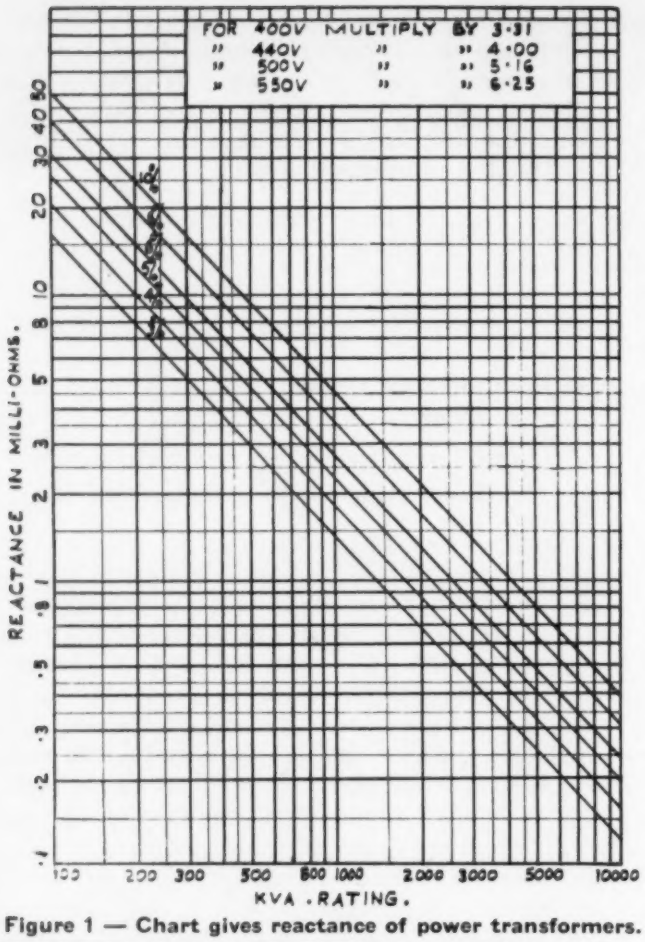


Figure 1 — Chart gives reactance of power transformers.

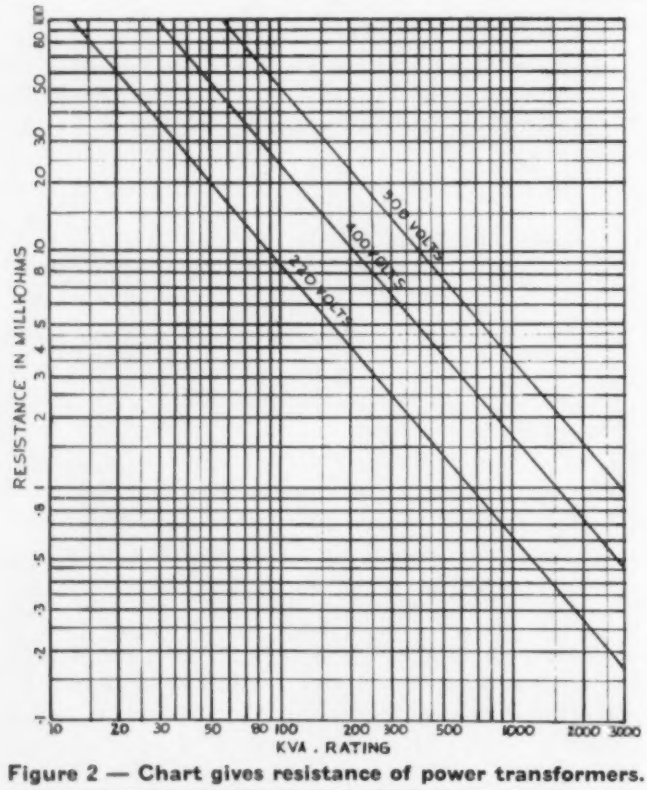


Figure 2 — Chart gives resistance of power transformers.

5. Cables and overhead lines—Resistance and reactance values of different sizes of wires and cables are given in standard books. For low voltage systems, reactances of short-length heavy-section wires and bus-bars also play appreciable part in limiting the short-

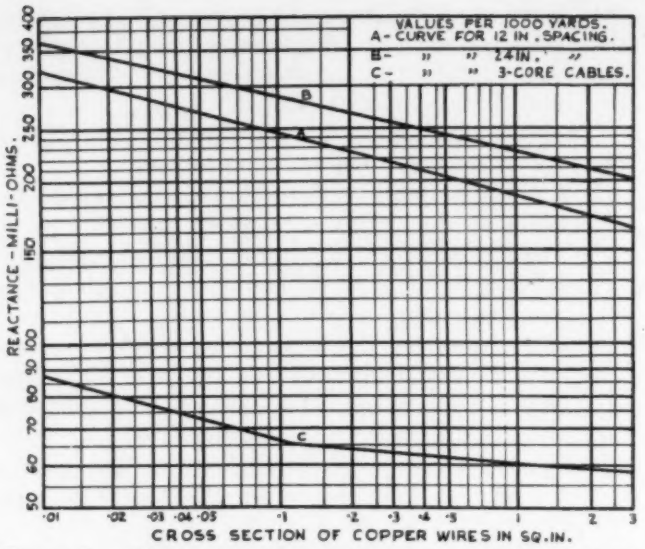

VALUES PER 1000 YARDS.
A- CURVE FOR 12 IN. SPACING.
B- " " 24IN. "
C- " " 3-CORE CABLES.
REACTANCE - MILLI-OHMS.
CROSS SECTION OF COPPER WIRES IN SQ.IN.

Figure 3 — Chart gives reactance value per 1000 yards for various sized copper wires.

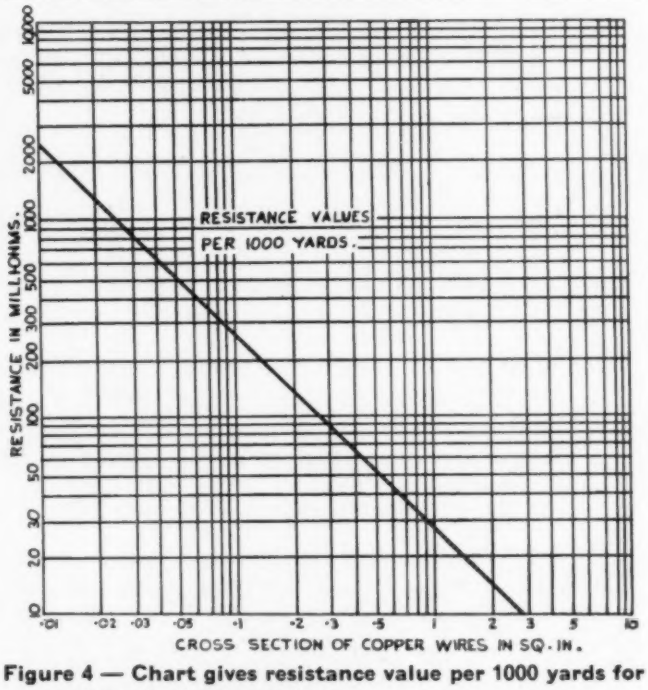


Figure 4 — Chart gives resistance value per 1000 yards for various sized copper wires.

circuit currents. For a general calculation of reactance, the following equation can be used:

$$X \text{ (in ohms per mile)} = \frac{2\pi f}{1000}\left(0.1021 + 0.741 \log_{10}\frac{d}{r}\right)$$

where f = frequency of supply.

d = mean-spacing between conductors in inches.

$$= \sqrt[3]{d_{1.2}\, d_{2.3}\, d_{3.1}}$$

r = radius of the conductor in inches.

For practical purposes, the effective values of impedance of short lengths of large size conductors and bus-bars will be small and can be neglected. This limitation may give 10 per cent to 20 per cent higher values of calculated currents, depending on the distance of the short-circuit fault from the power-source.

For ready reference, the values of reactances and

resistances for transformers and feeders have been given in Figures 1, 2, 3, and 4.

6. *Evaluation of short-circuit currents*—In Figure 5, the short-circuit curves for various values of resistances and reactances are indicated. The graph can be used as a reference, to find out the possible short-circuit currents in any practical system at any point of fault desired. The graph is based on "per unit" values of impedance of the short-circuit path, taken on the basis as follows:

100 milli-ohm resistance = 1 per unit resistance
100 milli-ohm reactance = 1 per unit reactance
100 volts per phase = 1 per unit voltage.

The per unit short-circuit current will then be:

$$\frac{1 \text{ per unit volt}}{1 \text{ per unit reactance}}$$

if the resistance is neglected. Hence 1 per unit current will be equal to 1000 amperes.

In Figure 5, a circle drawn with a radius of 1 per unit ohm reactance represents a locus of 1 per unit ampere current. Abscissae represent per unit resistance and ordinates represent per unit reactance. To find the actual short-cicuit current, suppose the values of resistances and reactances per phase up to the short-circuit point are 30 milli-ohms and 20 milli-ohms respectively. Then in the diagram, OA = 0.3 per unit resistance, and OB = 0.2 per unit reactance. The lines AB and CB are drawn parallel to the two axes to meet in B. Then OD = OB is cut off on the reactance axis, which is equal to 0.36. The short-circuit current per unit volt will therefore be:

$$\frac{1}{0.36} \times 1 = 2.78 \text{ per unit ampere} = 2780 \text{ amperes}$$

A circle drawn with OD which represents the circuit impedance as radius therefore represents a locus for 2780 amperes with 100 volts per phase.

To find out the three-phase short-circuit current for any circuit, it is required to calculate the total resistance and reactance per phase of the short-circuit loop and find out the current value from the graph.

In Figure 5, the curves for currents are drawn for 1 per unit voltage, i.e. for 100 volts per phase. The multiplying factors for the various standard three-phase voltages are as follows:

For 3-phase 500 volts — multiply by 2.89
For 3-phase 440 volts — multiply by 2.54
For 3-phase 400 volts — multiply by 2.30
For 3-phase 220 volts — multiply by 1.27

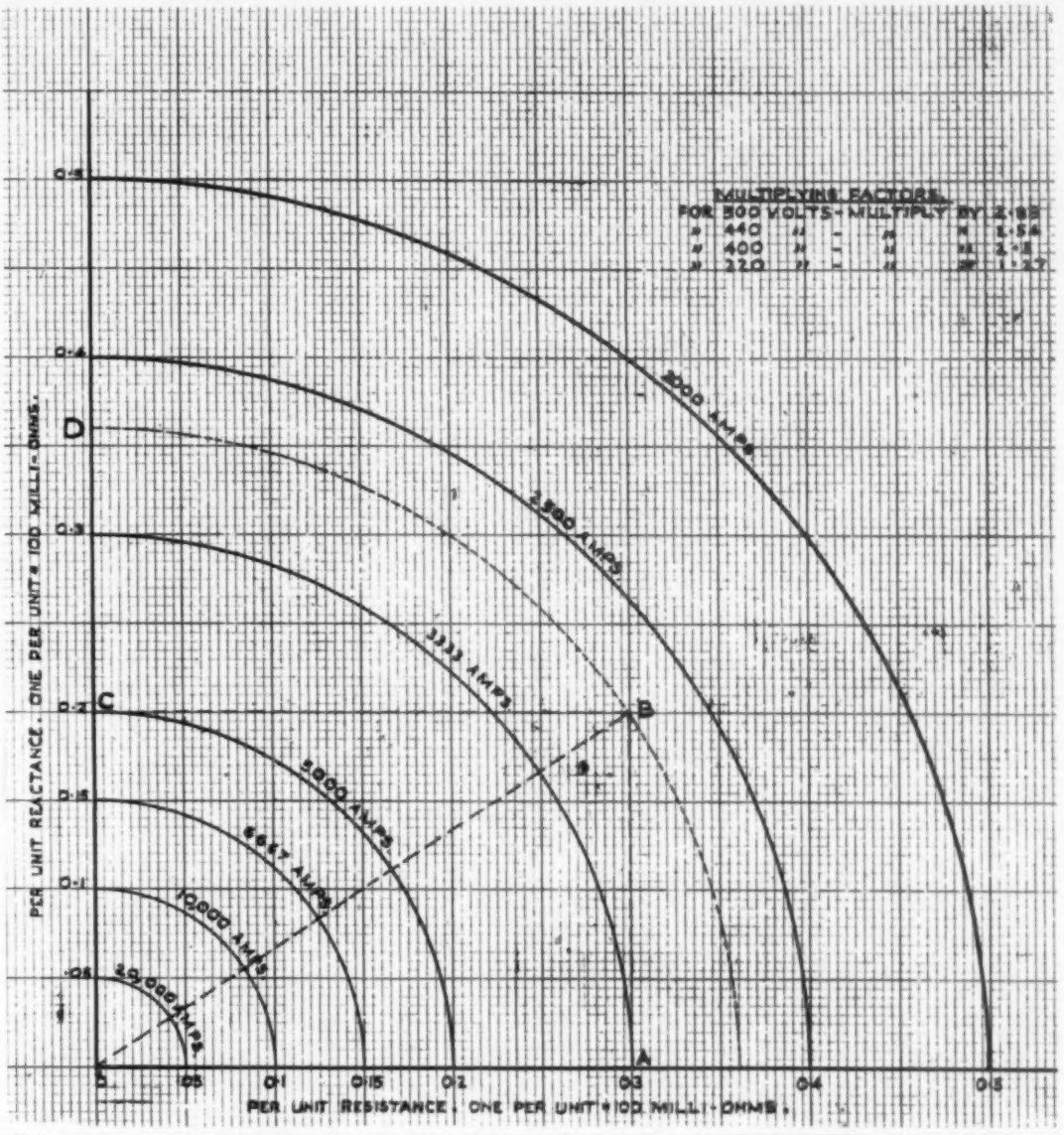


Figure 5—Curves show short-circuit based on one per unit, i.e., 100 volts.

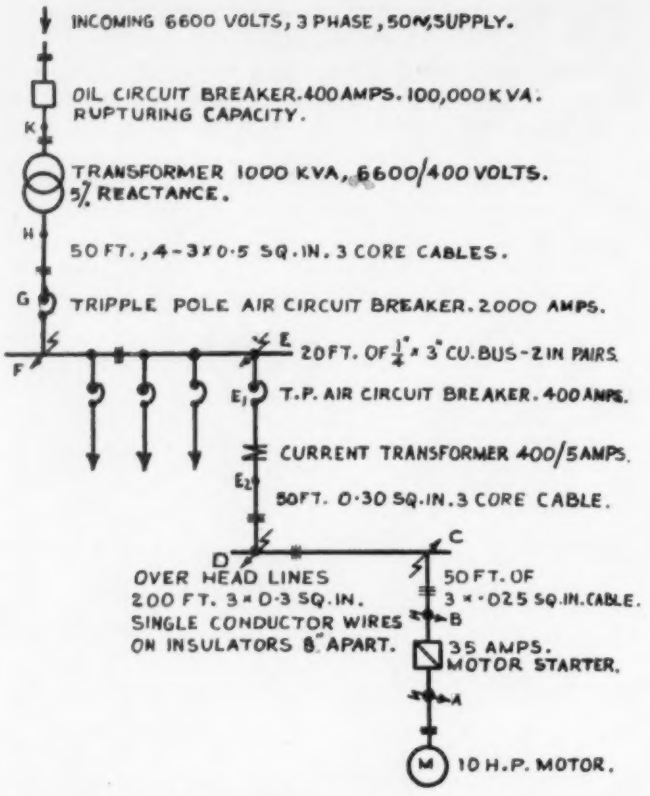

INCOMING 6600 VOLTS, 3 PHASE, 50~ SUPPLY.
OIL CIRCUIT BREAKER. 400 AMPS. 100,000 KVA. RUPTURING CAPACITY.
K
TRANSFORMER 1000 KVA, 6600/400 VOLTS. 5% REACTANCE.
H
50 FT., 4-3×0·5 SQ. IN. 3 CORE CABLES.
G
TRIPPLE POLE AIR CIRCUIT BREAKER. 2000 AMPS.
E
F
20 FT. OF 1/4" × 3" CU. BUS-2 IN PAIRS.
E1
T.P. AIR CIRCUIT BREAKER. 400 AMPS.
CURRENT TRANSFORMER 400/5 AMPS.
E2
50 FT. 0·30 SQ. IN. 3 CORE CABLE.
C
D
OVER HEAD LINES 200 FT. 3×0·3 SQ. IN. SINGLE CONDUCTOR WIRES ON INSULATORS 8" APART.
50 FT. OF 3×·025 SQ. IN. CABLE.
B
35 AMPS. MOTOR STARTER.
A
M
10 H.P. MOTOR.

Figure 6 — Schematic diagram of a typical low voltage distribution layout.

Figure 6 illustrates a typical low voltage installation for short-circuit consideration. Various details are given in the figure. The short-circuit faults are assumed at points A, B, C, D and E to indicate how the different sizes of conductors, circuit breakers and starters affect the short-circuit current. The short-circuit power available at the 6900-volt side of the incoming is assumed to be 100,000 kva only.

The values of resistances and reactances for each position of the fault are given in Table II and the calculated short-circuit current values in Table III.

Comparison of the values in Table III leads to the inferences as follows:

1. If the fault lies further away on a sub-branch circuit, the bus-bars, breakers, main leads and the current-transformers have negligible effect on the total short-circuit currents.
2. The impedance of the high tension system has a negligible effect, even in a system having 100 mva short-circuit capacity at the high tension side. The primary voltage can thus be assumed to remain steady even with a short-circuit fault at the low tension terminals of the main 440-volt power transformer.
3. Current-limiting effect of a small starter in the path of the short-circuit is very appreciable. A 30-amp motor-starter reduces the short-circuit current by about 15 per cent.
4. For faults very near the main sub-station, the effects of reactances of circuit-breakers, bus-bars, current-transformers and heavy section conductors become cumulative and should be considered for correct evaluation of maximum short-circuit current. Currents obtained by neglecting those values will be about 20 per cent to 40 per cent higher.

SELECTION OF CIRCUIT BREAKERS FOR THE UNIT SUBSTATION

In case of the modern factory-assembled unit substation, the connections between transformer and the 440-volt main incoming switch will be over heavy section short-length copper bus. The total reactance from the transformer terminals to point G on the main circuit-breaker would be about 1.00 milli-ohm. The total reactance up to point F of the main bus-bars would be about 10.6 ohms, including the high tension system reactance. The total instantaneous symmetrical short-circuit current available for a 1000-kva transformer unit substation at 440 volts would be about 24,000 amp. It means that a standard 50,000-amp rating circuit-breaker should be provided as the main incoming breaker. For a feeder breaker having a series overcurrent trip and a current-transformer in each phase, additional reactances introduced by the breaker unit itself will be at least 2.0 milli-ohms. The total reactance immediately after the feeder breaker will

TABLE II

Reactance and Resistance Values at Various Points in Figure 6

Circuit number	Reactance in milli-ohms	Resistance in milli-ohms
Utility system	1.60	.....
Transformer	8.00	1.75
From H to G	0.25	0.20
From G to F	0.0022	.....
Total from K to F	9.8522	1.95
Total from F to E	1.125	.....
Total from K to E	10.9772	1.95
Total from E to E_1	1.85	.....
Total from E_1 to E_2	0.39	.....
Total from E_2 to D	1.12	1.336
Total from K to D	14.337	3.286
Total from D to C	19.500	5.800
Total from K to C	33.837	9.086
Total from C to B	1.260	16.920
Total from K to B	35.097	26.006
Total from B to A	7.000	.....
Total from K to A	42.097	26.006

TABLE III

Short Circuit Currents at Various Points in Figure 6 for 400-volt, 3-phase, 50-cycles, a-c System (3-phase solid short circuits assumed)

Fault position	Calculated current, amp
Point A	4650
Point B	5125
Point C	6570
Point D	15,335
Point E	20,910
Point F	23,000

therefore be about 12.6 milli-ohms, giving a maximum symmetrical instantaneous short-circuit current of about 20,000 amp. The momentary short-circuit rating of the circuit-breaker would be 25,000 amp. For outgoing feeders, it is therefore possible to use 25,000-amp interrupting rating circuit-breakers.

In steel plants, therefore, with 1000-kva unit substations, the most economical and fairly safe solution should be to provide 5 per cent impedance transformer, 50,000-amp interrupting rating main circuit-breaker and 25,000-amp interrupting rating feeder breakers. In case, two 1000-kva substations are to be operated in parallel, then it would become necessary to provide all the breakers with 50,000 amp interrupting rating.

From the viewpoint of safety of operations, circuit-breakers having rating higher than 50,000 amp should be remote operated. It will thus be desirable to plan out the 440-volt system in steel plants in such a way that load-center unit substations are limited to 1000 kva transformer capacity.

PROTECTION OF SUB-CIRCUITS

Once the maximum possible short-circuit current at a point in a system is determined, it is necessary to decide on the nature of protection for each individual sub-section, i.e. the motor, the starter and the branch circuit. It is also desirable to demarcate a dividing line between what can be termed overloads and short-circuits. It can be assumed that over 10 times the rated current constitutes a short-circuit condition. Above 10 times the rated current, the effective thermal capacity will be proportional to the copper contents in the stator-winding of the motor, in the control and the branch circuit. To protect the equipment through which the short-circuit current passes, it is therefore necessary to use a device that is both fast in opening and has sufficient interrupting ability. The interrupting ability of a protecting device is a very important consideration, because it is essential that in trying to open the circuit on fault, the protecting device does not itself get destroyed.

CURRENT-TIME HEATING CHARACTERISTICS OF INDUCTION MOTORS

In order to effectively protect a motor from overheating, it is necessary to decide what constitutes an excess temperature. For class A insulation, the maximum safe temperature of copper conductor is fixed at 110 C, while with class B insulation it is fixed at 130 C. Thus in an ambient of 40 C, it is safe for class A insulated motors to allow the conductor copper to operate at a temperature of 70 C over the ambient.

However, where temperatures are transient and last for only a few seconds and occur infrequently, a higher temperature rise can be permitted. Such conditions occur when a motor gets stalled or is started directly on the power line at full-voltage, provided it is not called upon to withstand that condition frequently unless specially designed for the service. It can safely be assumed that a total temperature of 170 C under short-circuit conditions, if allowed to occur only infrequently and that too for a few seconds, can be allowed as the upper temperature limit for motor stator copper. It is, of course, not the limit to which it is permissible to carry copper with its insulation, but where the wire is selected for its continuous current carrying capacity, its resultant temperature under short-circuit conditions can be taken to be in accordance with the above assumption.

A normal induction motor running at its rated load, has one-third of its total heat-loss produced by the iron and two-thirds by the copper. If however, the motor stalls and takes five times the current, the iron loss remains still the same, but the copper loss becomes twenty-five times. Thus under the stalled condition, the iron temperature can be assumed to be stationary while the copper reaches its limit.

Under certain conditions, it is possible to draw a graph showing the current-time characteristics of an induction motor which gives a good overall picture of the motor heating from continuous full load to heavy short-circuits.

Figure 7 gives the representation of the heating characteristics of induction motors, based on current density of stator conductor copper. The current density of the standard line of motors falls within 1000 to 3000 amp per sq in., when carrying the rated full-load current. The curves are calculated on the following basis:

1. It is assumed that before the overload is applied, the temperature of stator copper was at 70 C. The maximum total temperature to which the copper is allowed to rise under overload conditions is limited to 170 C.
2. For duration of 30 seconds and below, no heat is supposed to be dissipated. All the generated heat remains concentrated in the copper.
3. Under full load conditions, the copper reaches its specified temperature rise in about 20,000 seconds.
4. Current-time curves are calculated on the basis of the following equation:

$$I = 0.22 \times 10^6 \times A \sqrt{\frac{1}{t} \log_{10} \frac{Q_2 + 234}{Q_1 + 234}}$$

where I = current in amperes,

A = cross-section of the stator conductor in sq in.

Q_1 = initial temperature of conductor in C.

Q_2 = final temperature of conductor in C.

For $Q_1 = 70$ C and $Q_2 = 170$ C,

we have, $t = 6000 \times 10^6 \times \left(\frac{A}{I}\right)^2$

In Figure 7, each curve is shown to have one slope between 20,000 seconds and 30 seconds, and another slope between 30 seconds and 0.1 second. The point at 20,000 seconds shows that the motor carrying its full load continuously will attain its specified temperature rise in 20,000 seconds. If at that point, the motor is overloaded, its temperature rise goes on increasing until it reaches 100 C rise. Up to 30 seconds, the heat generated in the copper tends to be dissipated depend-

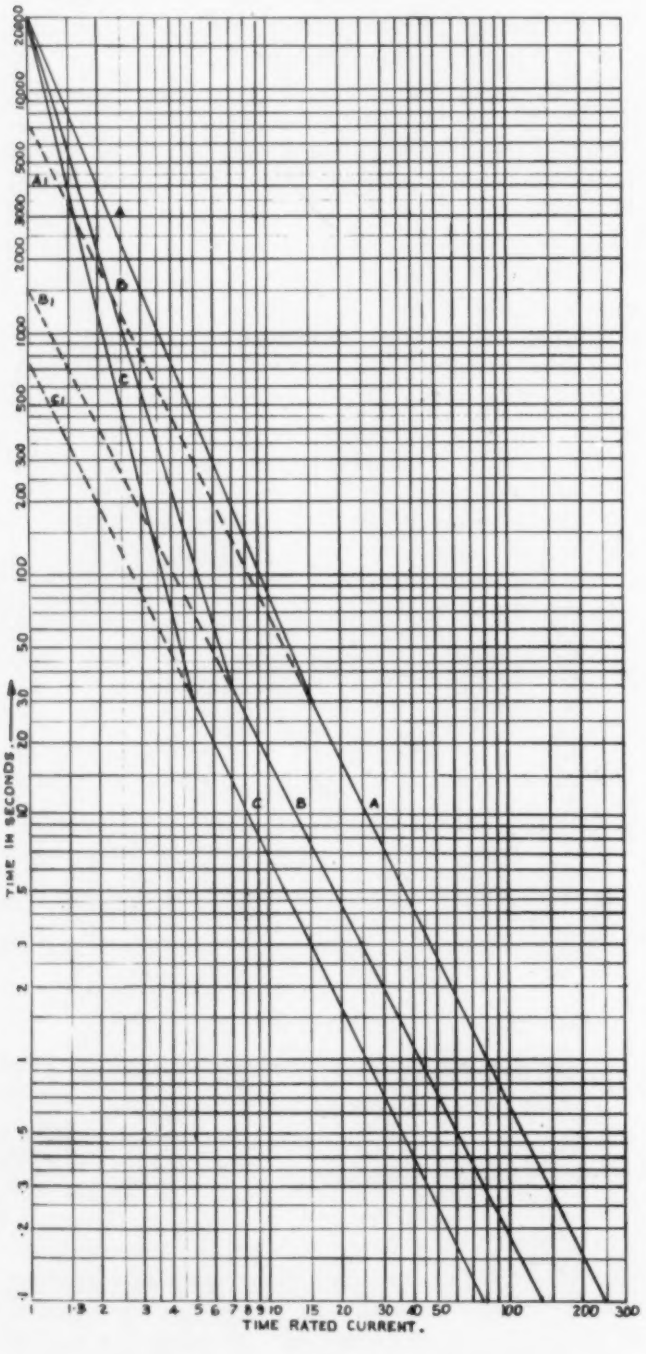
ing on the current and the period for which it is allowed to flow. Thus the copper will reach a temperature rise of 100 C (i.e. 170—70=100), if about eight times the full load current is allowed to flow for 30 seconds, with a motor winding designed for a current density of 2000 amp per sq in. The curve between 20,000 and 30 seconds gives the permissible overload-time condition of the motor stator.

Below 30 seconds, all the heat generated is assumed to remain concentrated in the copper, which thus gives a different slope. The dotted part of the curve shows the current-time relationship from 30 seconds upwards, if no dissipation of heat was considered which can be calculated from the given equation.

The curves between 20,000 and 30 seconds give the permissible current-time relationship for motor overload conditions, while the curves between 30 and 0.1 seconds give the current-time relationship under short-circuit conditions.

The curves give a good working method, correlating the copper thermal capacity on the basis of the current density used for the motor design. The values obtained are sufficiently close for all practical purposes and can be gainfully utilized to decide the starting and stalling limits of motors related to the protective equipment.

Figure 7 — Heating characteristics of 3-phase induction motors.



CURRENT-TIME CURVES FOR COPPER, SHOWING RATE OF HEATING FOR FIXED CURRENT DENSITIES AT RATED CURRENT AND MAXIMUM TEMPERATURE RISE OF 100 DEG. C.
CURVE A — CURRENT DENSITY 1,000 AMPS. PER SQ. IN.
" B " " 2,000 " " " "
" C " " 3,000 " " " "

CHARACTERISTICS OF MOTOR STARTERS ON SHORT-CIRCUITS

The standard motor starters are provided with heater-type bi-metal overload relays. The heater coils thus introduce an impedance into the motor circuit, which tends to reduce the short-circuit current depending on the size of the starter. The reactances of the starters with the current rating are given in Table I. The impedance of a starter is equivalent to about 10 volt-amp per phase at the rated current. For the purpose of estimating the maximum short-circuit current which a motor-starter permits to go through, the impedance of the starter can be assumed to be equivalent to 10 va.

If the total impedance of the circuit to which a motor starter is connected is 10 milli-ohms and the starter impedance is equivalent to 10 volt-amperes, it is possible to calculate the maximum short-circuit current which can flow through a motor-starter.

Figure 8 gives the relationship between the current rating of the motor-starter and the maximum short-circuit current which can pass through the starter for a 440-volt supply system. The currents are given in rms symmetrical values.

Depending on the heating characteristics of the nichrome wire of the heater of the overload relay of the starter, each starter has its maximum short-time current carrying capacity. If we take 1350 C as the limit temperature to which a nichrome heater can be allowed to reach momentarily and the starter copper to rise to 125 C as a safe maximum momentary limit, the curves in Figure 9 indicate the interrupting speeds required to fully protect motor-starters against specified short-circuit-currents.

Referring to Figure 8, it is observed that a 20-amp starter permits a through-short-circuit current of about 7250 amperes, whereas Figure 9 shows that only about 3500 amperes can safely flow for a duration of 0.008 second only. Since the heating varies as the square of the current, 7250 amperes can be allowed to flow through the starter only for

$$\left[\frac{3500}{7250}\right]^2 \times 0.008 = 0.00188 \text{ second.}$$

It is therefore to be appreciated that to protect a 20-amp starter against short-circuit in a system having

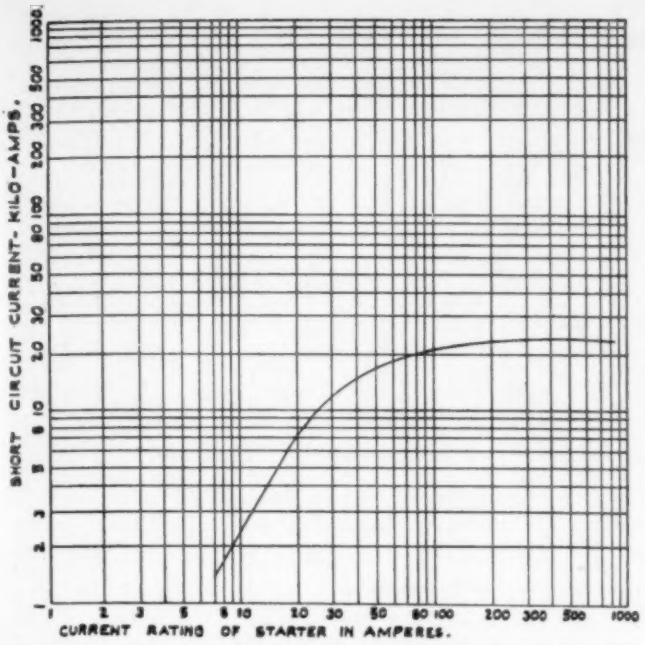


Figure 8 — Magnitude of short-circuit current is given for circuit in which 10 volt-ampere per phase is assumed for the total impedance of the circuit when carrying the rated current.

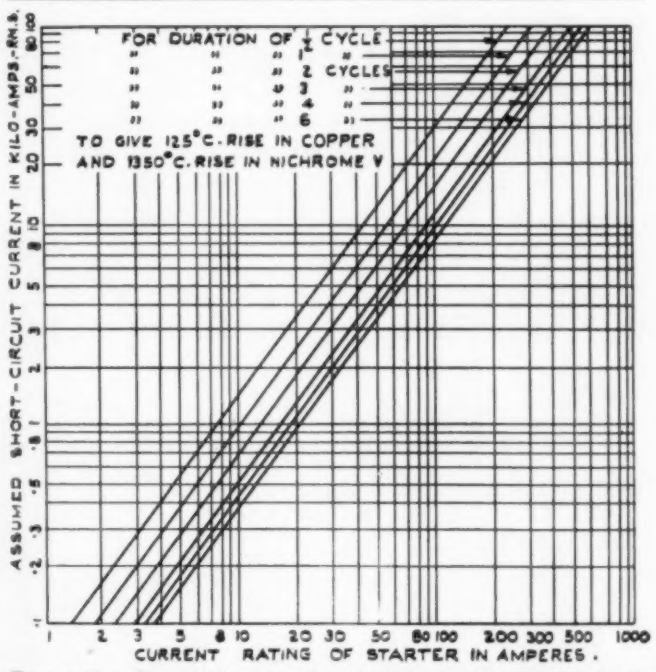

FOR DURATION OF ½ CYCLE
" " " 1 "
" " " 2 CYCLES
" " " 3 "
" " " 4 "
" " " 6 "
TO GIVE 125°C. RISE IN COPPER
AND 1350°C. RISE IN NICHROME V
ASSUMED SHORT-CIRCUIT CURRENT IN KILO-AMPS.-R.M.S.
CURRENT RATING OF STARTER IN AMPERES.

Figure 9 — Curves give required interrupting speed to fully protect starters having heater-type overload relays against specified short-circuit currents.

about 25,000-amp short-circuit current capacity, it is necessary to provide a protective device which can operate within the time limit of a milli-second. Such speeds are obviously much faster than of any circuit-breaker, which can have at the best speeds in the order of 0.008 second. Thus a circuit-breaker obviously is not always the best short-circuit protection for a small motor-starter.

INTERRUPTING SPEEDS OF FUSES

The modern fuse is perhaps the most effective short-circuit protection for small motor-starters, as a fuse can be designed for a fusing speed of the order of a milli-second or less.

In considering the interrupting speeds of fuses, two factors are to be looked into, namely the time in which the circuit is interrupted and the available energy which is to be interrupted. The time of interruption of a fuse consists of two distinct parts, viz. the period required to melt the fuse and the period required to interrupt the circuit. The ratio of the fuse melting time and the circuit interrupting time can be taken as 1:2. It is the total time of interruption of the circuit that is to be considered in short-circuit protection.

Figure 10 gives the time in milli-seconds required to melt a certain design of fuse-links (zinc). Melting point of zinc is 419 C. Referring to the curve for 60-amp fuse, it will be seen that the 60-amp zinc fuse interrupts 7250 amp in about 0.00125 second. This means that 60-amp fuse does not permit the short-circuit current to materially exceed the value at melting. The current will then start decreasing during the interrupting period until the circuit is completely interrupted.

To protect a 20-amp starter with a heater-type relay, it is essential that the maximum size of the fuse for short-circuit protection should not exceed 60 amp.

INTERRUPTING ABILITY OF FUSES AND CIRCUIT BREAKERS

In plants where it becomes necessary to provide load-center unit stations of capacity higher than 1000 kva, or operate two 1000 kva units in parallel, it is necessary to weigh carefully as to what type of short-circuit protection should be provided for motors up to 100-amp full-load current capacity.

Steel plant engineers often prefer to have automatic circuit-breakers in preference to fuses to be incorporated in motor-starters, even for smaller motors for protection against short-circuits, because fuses require a longer time for replacements, whereas an automatic breaker can be readily switched-in after a trip-out.

Figure 10 — Chart gives time required for low voltage zinc fuse links to melt.

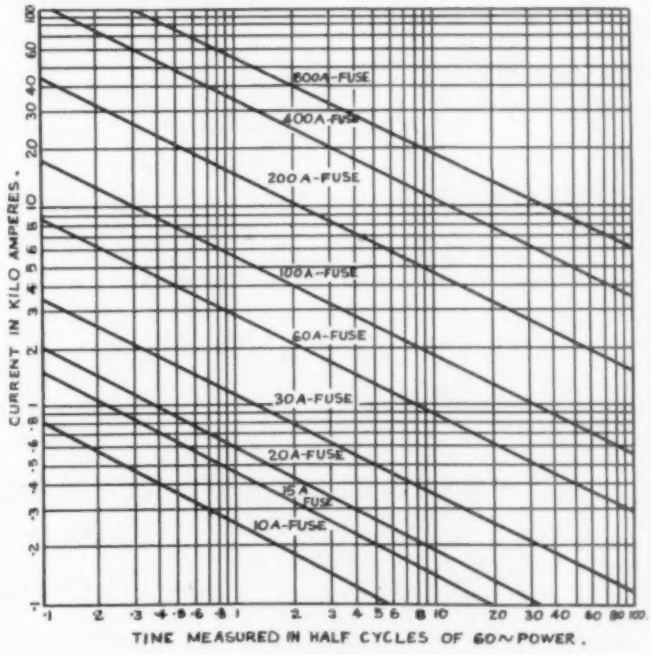


TABLE IV

Comparison Between Circuit Breakers and Fuses Under Short-circuit Operation

	Circuit breakers			Fuses		
1. Rating — amp	25	50	100	30	60	100
2. Current interrupted, I (amp)	6,000	8,000	10,000	2,000	4,500	7,500
3. Time of interruption, (t) sec	0.0123	0.012	0.0124	0.0025	0.006	0.009
4. Values of I^2t	288,000	352,000	582,000	5,500	62,000	170,000

In the paper published in a previous issue of The Iron & Steel Engineer, (See 1951 Proceedings AISE, p 328) the comparative characteristics of fuses and circuit-breakers for short-circuit protection for sizes up to 100 amperes have been discussed. The comparison of the characteristics between 30, 60 and 100-amp fuses and automatic circuit-breakers can be taken from Table IV.

It will be observed that the circuit-breaker permits a much higher current to pass through and also takes a comparatively longer time to interrupt the circuit. The heating of the affected equipment is proportional to I^2t value (i.e. current squared into time) and therefore with the automatic circuit-breaker, a starter which is provided with a heater-type overload relay is likely to get damaged before the breaker could interrupt the circuit. The main reason for the frequent burn-outs of starters for small motors under motor circuit faults can therefore be attributed to the wrong application of the short-circuit protection.

SUMMARY

It is necessary that planning engineers should pay as much attention to the layout of low voltage power supply in modern steel mills, as is being paid to the high tension distribution from the viewpoint of limiting the system short-circuit power.

The use of modern load-center unit substations properly located at the required load-centers would reduce the size of the transformers. The load-centers should preferably be kept within 1000 kva transformer sizes, so that the standard and more economical 25,000-amp interrupting rating breakers can be used on outgoing feeders. The size of the feeder breakers should be limited to a maximum of 50,000-amp interrupting rating, which means that two 1000-kva transformers should be the maximum size for a load-center unit substation, in case continuity of power supply is essential, requiring two transformers in parallel.

For motors and starters of 100-amp rating and below, the most economical and best short-circuit protection is given by the modern high interrupting capacity one-time fuses. It is in fact not a good and safe practice to use an automatic circuit-breaker as a short-circuit protection for small motors in systems having short-circuit currents higher than 15 to 20,000 amp.

Tube Mill Practice

A selection of articles from the IRON AND STEEL ENGINEER on various phases of tubemaking.

Practical information on layout and operation of facilities for seamless, butt and electric weld pipe, a field in which little information has been published... 23 articles by 20 authoritative writers ... invaluable for engineers, operators, trainees and students.

8-¼ x 11-¼ in.,.....196 pages, illustrated, clothbound
Price: To AISE Members...$2.00
To Others.....$4.00

ASSOCIATION OF IRON AND STEEL ENGINEERS
1010 Empire Building
Pittsburgh (22), Pa.

Tentative Program

Association of Iron and Steel Engineers

1956 AISE ANNUAL CONVENTION AND IRON AND STEEL EXPOSITION

CLEVELAND PUBLIC AUDITORIUM
CLEVELAND, OHIO

September 25, 26, 27, 28

Tentative Program

ASSOCIATION OF IRON AND STEEL ENGINEERS

1956 AISE ANNUAL CONVENTION

AND

IRON AND STEEL EXPOSITION

CLEVELAND PUBLIC AUDITORIUM

CLEVELAND, OHIO

September 25, 26, 27, 28

Tuesday, September 25, 1956

9:00 am — REGISTRATION — Main Lobby

9:15 am — BUSINESS MEETING — Ballroom

Conducted by President W. H. Collison

9:30 am — ELECTRICAL SESSION — Ballroom

Chairmen: Ray T. Winterringer, Assistant Superintendent Electrical Department, South Chicago Works, Republic Steel Corp., Chicago, Ill.

Richard G. Nolan, Electrical Engineer, Granite City Steel Co., Granite City, Ill.

"Electrical Equipment for Continuous Annealing of Silicon Steel Strip," by G. J. Hay, Steel Mill Engineer, Westinghouse Electric Corp., East Pittsburgh, Pa., and Hugh S. Fegeley, Control Design Engineer, Westinghouse Electric Corp., Buffalo, N. Y.

"Application of Speed Controls for Hot Strip Finishing Mills," by George S. Koss, Superintendent Plate, Slab and Strip Mill and Louis E. Ringger, General Supervisor, Electrical Engineering, Columbia-Geneva Steel Division, United States Steel Corp.

"Electrical Features of a Hot Strip Mill Reversing Rougher with Close Coupled Edger," by J. H. Greiner, Application Engineer, Electrical Application Department, and A. Mozina, Engineer, Control Section, Allis Chalmers Manufacturing Co., Milwaukee, Wis.

9:30 am — BLAST FURNACE SESSION — Club Room B

Chairmen: J. H. Strassburger, Assistant Vice President, National Steel Corp., Pittsburgh, Pa.

George H. Greene, Assistant General Manager, Bethlehem Steel Co., Johnstown, Pa.

"Reducing Delays During the Blast Furnace Campaign Through Improvement of Mechanical Features," by W. O. Bishop, Superintendent, and Charles P. Frame, Mechanical Foreman, Plant 2 Blast Furnaces, Inland Steel Co., East Chicago, Ind.

"Automatic Split-Wind Blowing Equipment—Duquesne Works," by James S. Frazer, Jr., General Supervisor-Power and Fuel, Engineering Department, Duquesne Works, United States Steel Corp., Duquesne, Pa.

"Development of Tuyere Air Proportioning for the Blast Furnace," by E. K. Miller, Jr., Assistant Division Superintendent, Blast Furnaces, Gary Steel Works, United States Steel Corp., Gary, Ind.

2:00 pm — MECHANICAL SESSION — Club Room B

Chairmen: C. W. Bruce, Chief Engineer, Chicago District, Republic Steel Corp., Chicago, Ill.

Charles H. Good, Jr., Chief Engineer, Duquesne Works, United States Steel Corp., Duquesne, Pa.

"The Design of Mill Buildings," by J. J. Murray, Development Engineer, Jones & Laughlin Steel Corp., Pittsburgh, Pa., and Thomas C. Graham, Chief Design Draftsman, Design Engineering Department, Pittsburgh Works, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

"Treatment and Reuse of Mill Scale Wastes to Conserve Water and Abate Pollution," by Grant A. Pettit, Industrial Waste Control Engineer, Armco Steel Corp., Middletown, Ohio.

"Economics of Oxygen Generating Stations for Steel Mill High and Low Purity Oxygen Applications," by Arthur E. Steele, Manager, and Donald E. Cummings, Assistant Manager, Steel Mill Sales Division, Air Products, Inc., Allentown, Pa.

2:00 pm — COMBUSTION SESSION — Ballroom

Chairmen: R. A. Lambert, Superintendent Steam & Combustion, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

David Cousley, Assistant Superintendent Utilities, Wheeling Steel Corp., Steubenville, Ohio.

"The Relative Value of Various Gases for Scarfing," by W. M. Bloom, Combustion Engineer, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

"The Prevention of Gas Incidents," by T. A. Watson, Assistant Division Superintendent, Power Production, United States Steel Corp., South Works, Chicago, Ill.

"Control of Atmosphere Generators," by R. R. Swain, Manager Iron and Steel Division, Bailey Meter Co., Cleveland, Ohio.

Wednesday, September 26, 1956

9:00 am — ELECTRICAL SESSION — Ballroom

Chairmen: F. H. Wickline, Electrical Engineer, United States Steel Corp., National Tube Division, Pittsburgh, Pa.

Ernest F. Donatic, Assistant General Supervisor, Service Division, Kaiser Steel Co., Fontana, Calif.

"Greater Flexibility for Wire Drawing," by R. C. Suttle, Reliance Electric & Engineering Co., Cleveland, Ohio, and Maurice A. Nye, Chief Engineer, The Vaughn Machinery Co., Cuyahoga Falls, Ohio.

"Electrical Maintenance at the Pueblo Plant of the Colorado Fuel & Iron Corp.," by H. E. Watson, Electrical Superintendent, The Colorado Fuel & Iron Corp., Pueblo, Colo.

"Protection of Men Exposed to the Hazards of Moving Overhead Electric Cranes, by Harold R. Miller, General Foreman Assigned Maintenance, Butler Works, Armco Steel Corp., Butler, Pa.

9:00 am — COMBUSTION SESSION — Club Room B

Chairmen: Frank C. McGough, Superintendent Power & Fuel, Detroit Steel Corp., Portsmouth Works, Portsmouth, Ohio.

H. B. Helm, Fuel Engineer, Youngstown Sheet & Tube Co., East Chicago, Ill.

"Normalizing and Heat Treating of Steel Plate," by Horace Drever, President, Drever Co., Bethayres, Pa.

"Studies of Surface Stains on Annealed Cold Rolled Steel,"

Part I — "Types of Defects and Their Occurrence," by C. R. Lillie, Research Metallurgist and D. W. Levinson, Supervisor, Non-ferrous Metals Research, Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill.

Part II — "Identification and Reaction Mechanisms," by F. Schossberger, Senior Scientist, K. Hattori, Research Chemist, and H. Marver, Assistant Chemist, Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill.

"Modernization of Wheel Heating Facilities, Johnstown Plant, Bethlehem Steel Co.," by F. R. Pullen, Fuel Engineer, Bethlehem Steel Co., Johnstown, Pa.

2:00 pm — OPERATING PRACTICE SESSION — Ballroom

Chairmen: Robert W. Holman, Director of Control Mechanisms Research, United States Steel Corp., Research & Technology Division, Pittsburgh, Pa.

S. O. Evans, Manager Tubing Operations, Babcock & Wilcox Co., Tubular Products Division, Beaver Falls, Pa.

"Nuclear Technology and the Steel Industry," by R. P. Peterson, Director Nuclear Research, Republic Steel Corp., Cleveland, Ohio.

"Transportation Control in Steelmaking," by J. L. Kerins, General Transportation Manager, Steel Operating Division, United States Steel Corp., Pittsburgh, Pa.

"Pipe: Manufacture and Use," by P. D. Thomas, Materials Engineer, Asiatic Petroleum Corp., New York, N. Y.

2:00 pm — LUBRICATION AND PAINT SESSION — Club Room B

Chairmen: Donald E. Whitehead, General Lubrication Engineer, Crucible Steel Co. of America, Pittsburgh, Pa.

Charles T. Lewis, Chief Lubrication Engineer, Republic Steel Corp., Cleveland, Ohio.

"Solvent Degreasing — A Valuable Industrial Cleaning Process," by W. L. McCracken, Director of Research, Detrex Corp., Detroit, Mich.

"Evaluation and Specification of Paint for Industrial Use," by Joseph Bigos, Senior Fellow, Mellon Institute, and Director of Research, Steel Structures Painting Council, Pittsburgh, Pa.

"Silicone Lubricants and Protective Coatings in the Steel Industry,"

Part I — "Silicone Lubricants," by W. H. Ragborg, Laboratory Supervisor, and W. H. Badger, Development Engineer, Fluids Section, Products Development Laboratories, Dow Corning Corp., Midland, Mich.

Part II — "Silicone Protective Coatings," by R. C. Hedlund, Supervisor, Coatings Laboratory, Product Development Laboratories, Dow Corning Corp., Midland, Mich.

6:30 pm — OLD TIMERS' DINNER

Thursday, September 27, 1956

9:00 am — OPERATING PRACTICE SESSION — Ballroom

Chairmen: George L. Bottcher, Chief Engineer, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

Warren E. Hart, Superintendent Electric Furnace Building, Ford Motor Co., Rouge Plant, Dearborn, Mich.

"Experimental Results with Hollow Electrodes in Electric Steel Furnaces," by W. E. Schwabe, Product and Process Development Laboratory, National Carbon Co., Niagara Falls, N. Y.

"Maximum Economical Size of the Top Charge Electric Furnace," by Wm. B. Wallis, President, Lectromelt Furnace Co., A McGraw Electric Co. Division, Pittsburgh, Pa.

"Basic Hot Blast Cupola as Source of Hot Metal for Steel Plants," by E. S. Harman, President, E. S. Harman Corp., Chicago, Ill. and Siegfred Tunder, Technical Director, Gesellschaft fur Huttenwerksanlagen, Dusseldorf, Germany.

9:00 am — LUBRICATION SESSION — Club Room B

Chairmen: C. A. Bailey, Lubrication Engineer, United States Steel Co., National Tube Division, Pittsburgh, Pa.

Andrew Cichelli, Lubrication Engineer, Bethlehem Steel Corp., Construction & Engineering Department, Bethlehem, Pa.

"Measurements for the Consistency of Lubricating Greases," by Ben Holliday, Chemist, Materials Engineering Division, Crucible Steel Co., Midland, Pa.

"High Temperature Steel-Mill Greases," by John Simon, Lubrication Engineer, National Works, National Tube Division, United States Steel Corp., McKeesport, Pa.

"Stopping Corrosion by the Use of Rust Preventive Compounds," by R. P. Mills, Manager, Rust Preventive Division, Valvoline Oil Co., Division Ashland Oil and Refining Co., Freedom, Pa.

7:00 pm — FORMAL DINNER AND DANCE — Ballroom

Norman Lewis will give a humorous talk called "The Kick in Life."

Friday, September 28, 1956

9:00 am — ROLLING MILL SESSION — Ballroom

Chairmen: R. A. Lambert, Superintendent Steam & Combustion, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

Don C. Horsman, Assistant General Superintendent, Continental Steel Corp., Kokomo, Ind.

"Seamless Tube Making by the Calmes Process," by Dr. Albert Calmes, Albert Calmes & Co., Milan, Italy, and Clyde Roberts, Chief Engineer, Phoenix Iron and Steel Co., Phoenixville, Pa.

"Backup Rolls and Their Contribution to Gage Variation," by Earl G. Lindsey, General Foreman-Roll Shop, Cold Reduction Department, Sheet and Tin Mill, Columbia-Geneva Steel Division, United States Steel Corp., Pittsburg, Calif.

"Weirton Modernizes Its Hot Mill," by L. A. Fugassi, Assistant Chief Engineer, Weirton Steel Co., Weirton, W. Va.

9:00 am — COMBUSTION SESSION — Club Room B

Chairmen: F. Bruce Bevelheimer, Power & Fuel Engineer, Ford Motor Co., Steel Division, Rouge Plant, Dearborn, Mich.

George H. Krapf, Division Superintendent, Power Production, United States Steel Corp., South Works, Chicago, Ill.

"An Automatic System of Fuel Control," by D. R. Mathews, Open Hearth Superintendent, Alan Wood Steel Co., Conshohocken, Pa.

"Modifications to the Fontana Open Hearth Precipitators," by E. V. Akerlow, Assistant Division Manager, Kaiser Engineers, Steel Division, Oakland, Calif.

"The All-Basic Open Hearth Furnace," by R. P. Heuer, Vice President, and M. A. Fay, Assistant General Sales Manager, General Refractories Co., Philadelphia, Pa.

2:00 pm — ELECTRICAL SESSION — Ballroom

Chairmen: Robert T. Lucas, Electrical Superintendent, Weirton Steel Co., Weirton, W. Va.

Clayton L. Squier, Assistant to Superintendent, Electrical Department, Bethlehem Steel Corp., Lackawanna, N. Y.

"Roughing Motor Inching Drives," by Dr. Roger Shields, Development Engineering Department, Elliott Co., Jeannette, Pa. and H. Kermit Fish, Assistant Electrical Superintendent, Weirton Steel Co., Weirton, W. Va.

"Automatic Gage Control for Cold Reduction Mills," by R. A. Phillips, Analytical Engineering Section, and H. S. Maxwell, Steel Mills Systems Application Engineering Section, General Electric Co., Schenectady, N. Y.

"Automatic Gage Control and Production Analysis on a "Z" Mill," by J. W. Hopper, Jr., Gage Application Engineer, Pratt & Whitney Co., West Hartford, Conn.

2:00 pm — OPERATING PRACTICE SESSION — Club Room B

Chairmen: H. R. Knust, Assistant to General Manager, Bethlehem Steel Co., Baltimore, Md.

H. A. Long, Chief Engineer, Pittsburgh Steel Co., Monessen, Pa.

"Equipment for Vacuum Melting and Processing," by C. E. Peck, Advisory Engineer, Industrial Heating Division, Westinghouse Electric Corp., Meadville, Pa.

"Automation and its Tooling and the Concept used at Inland Steel Co.'s New Rail Joint Line," by C. E. Chapman, Superintendent, Rail Accessories Department, Inland Steel Co.

"Edge Position Control for the Steel Strip Industry," by Frank J. Markey, Manager, Edge Position Controls Division, Askania Regulator Co., Chicago, Ill.

MISCELLANEOUS

Iron and Steel Exposition

Tuesday, September 25 ..... 10:00 am to 10:00 pm

Wednesday, September 26 ..... 10:00 am to 10:00 pm

Thursday, September 27 ..... 10:00 am to 5:00 pm

Friday, September 28 ..... 10:00 am to 4:00 pm

Transportation

For those not using trains or planes and not wishing to drive, arrangements have been made with the Greyhound Bus Co. to provide charter service for groups or companies.

Also, certain of their regular runs will be designated as the "Iron and Steel Exposition Excursion." Reduced rates will be in effect for this service.

Details and rates for both services can be obtained from your local Greyhound Agent.

Hotel Accommodations

Hotel reservations should be made direct to the hotel of your choice, giving time of arrival and type of accommodations desired. Reservations should state that they are for the AISE Convention. If they are unable to take care of you, they will forward your request to the Cleveland Convention Bureau, who will place you elsewhere.

Social Functions

Social Functions will take place at the Hotel Statler, which is the hotel headquarters for this convention. All other events will be held in the Cleveland Public Auditorium.

Ladies' Program

Tuesday, September 25 ..... Luncheon

Wednesday, September 26 ..... Luncheon

Thursday, September 27 ..... Kaffee Klatsch

Ingot mold foundries must be designed to fit a number of conditions such as available area, metal, molding materials, and many other factors .... all these must be taken into consideration in foundry design in order to get economical production of molds.

Figure 1 — Transferring iron from blast furnace to foundry pouring ladle.

Layout and Design of Ingot Mold Foundries

By GLENN W. MERREFIELD

Foundry Engineer, Giffels & Vallet, Inc., Detroit, Mich.

▲ THE making of ingot molds and stools, is now a production foundry process, and in the usual steel plant, a definite tonnage of these castings is required per day. The requirements are based on an estimate, related to the tonnage of steel ingot to be produced.

With the steel industry predicting a considerable increase in ingot making capacity in the next few years, the problem of facilities to make more ingot molds, together with that of making better molds, which will allow more pours per mold, is being given consideration.

In the United States and Canada the making of ingot molds has become a specialty, and both commercial foundries and captive foundries have developed highly mechanized foundries, to produce the ingot mold and stool castings. The foundry industry enters this picture in an important way, and as engineers of foundry facilities, will contribute in this paper some ideas, as to the present trends in the design of ingot mold foundry facilities.

The design of the many types of molds, with open end, closed end or bottle top, and other molds, will not be discussed in this paper, which will start with the patterns which have been made from the desired designs.

The extent to which the making of the ingot mold castings can be mechanized is limited somewhat by the size of the work involved, and the range of the different sizes and types of ingot molds and stools to be produced in a particular ingot mold foundry.

The handling and processing of the required volumes of sand and metal, as determined in the scope of a particular ingot mold foundry project, will determine the success of the project.

As material handling and processing are part of every foundry project, and in most foundry projects, about 150 tons of material are handled for every ton of castings produced, one can readily see that this specialized type of facility can require experienced engineering assistance. Many types of mechanical material handling equipment must be included in the design of an ingot mold foundry, varying from large overhead cranes, on down to a shovel. The choice of equipment thus requires careful consideration by the engineers.

Modern ingot mold foundry facilities require, not only good facilities and processes, but must also provide pleasant, healthy working conditions, with adequate heating and ventilating systems, and the required mechanization to reduce labor fatigue. With such

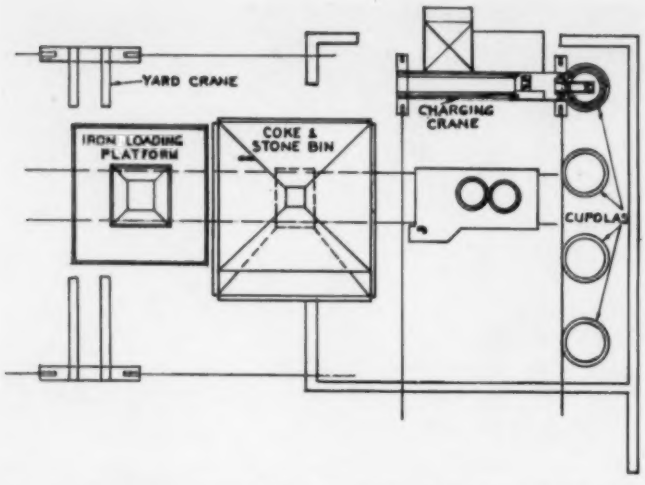


Figure 2 — Plan view shows cupola charging equipment.

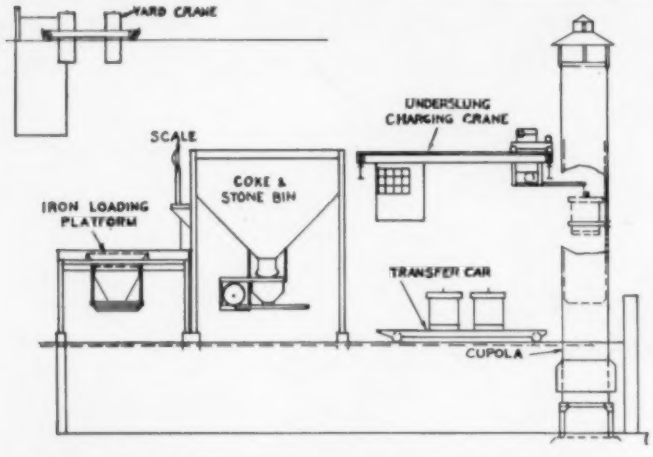


Figure 3 — Elevation of cupola charging equipment.

facilities, accidents to workers and equipment, can virtually disappear, maintenance costs can be substantially reduced, and equipment turnover, can be vastly improved.

The story of what improved facilities in ingot mold production can do, is now making history in some steel plants, and expressions like "200 per cent improvement in mold life" and "revolutionary performance" are now being used.

In the engineering of an ingot mold foundry, the project should be divided into two phases, the first of which can be called a preliminary engineering or survey phase. In this preliminary survey stage, all the facts regarding the production of various size ingot molds are gathered, both for present and future requirements. From these facts and figures, the engineer handling the project, starts to make a series of layouts, both in plan and section of the proposed project. Lines of flow, building requirements, equipment layout, manning, and all cost factors are given consideration. From this study, several alternate schemes are made, and discussions held, regarding the merits of the various proposed schemes, the cost of making molds by each, and estimated cost of the facility.

In making this study, the proposed operation is usually broken down into these divisions:

1. Material unloading and storage.
2. Melting and metal delivery.

Figure 4 — Cupola charge makeup car.

3. Sand handling, preparation and delivery.
4. Molding.
5. Core making.
6. Mold and core baking.
7. Mold closing.
8. Pouring and cooling.
9. Shakeout.
10. Ingot mold casting, cleaning and machining.
11. Storage and shipment of ingot mold castings.
12. Laboratory facilities.
13. Auxiliary departments such as pattern shop, pattern storage, repair areas, stockrooms, etc.
14. Employee facilities.
15. Building utilities such as power, fuel, water, compressed air, sewers, etc.
16. Site improvements.

Definite areas are allotted to each of the divisions, based on the space required for each, but generally 12 to 16 divisions, of the ingot mold foundry project are used.

The important consideration is of course to produce ingot mold castings and stools that will enable the client to have a low mold cost per ton of steel poured. Mold life, or the number of ingots that can be poured in a mold before it requires replacement, is the usual criteria by which an ingot mold foundry's operation is judged.

The two basic materials that go into getting good ingot molds and stools are metal and sand. Proper control of the variables in these two materials requires the best of facilities, and familiarity with the equipment that can limit the range of variables on metal and sand are required of the engineer on an ingot mold foundry project.

On the metal end, to name a few of the many controls that are required, comes analyses, metal temperature, pouring rate, cooling rate, and several others.

On the sand, grain size and screen distribution of the sand, type and analysis, bond materials, bond strength, moisture, permeability, green strength, dry strength and a number of other factors must be controlled.

Well designed facilities enables the operator of the ingot mold foundry, to keep these variables within narrow ranges, and the assistance of an experienced

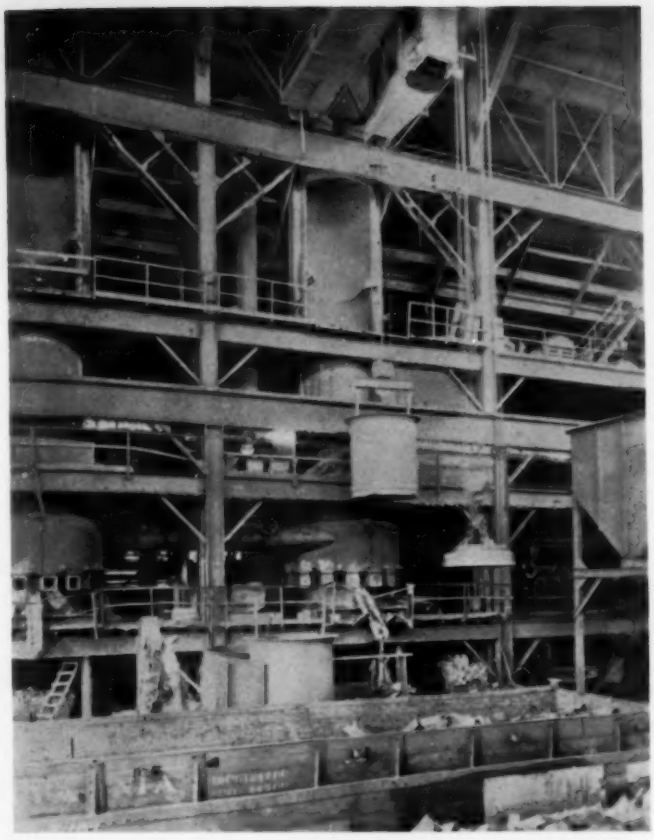


Figure 5 — Charging crane hoists charge bucket to charging door.

engineer on foundry facilities, with new ideas and a wide range of experience, can be used to good advantage.

In the preliminary study, the engineer must give consideration to the various processes of casting ingot molds, of which there are several, each of which has its advocates. He must be ready to abandon an old process in favor of a new on an ingot mold foundry project, and prescribe a process that fits into the conditions in the plant in which he is working.

From this preliminary survey, the proposed cost of the facilities are determined, a proposed cost of operation is made by manning the facilities, and a schedule worked out to put the proposed facility into operation.

By comparing this proposed cost of ingot mold castings with the present cost, the economics of the proposed facility can be determined.

Usually it is desirable to see savings made that will enable the proposed ingot mold foundry to pay for itself in a reasonable period of time.

Probable future expansion of the ingot mold facilities must be taken into consideration in the preliminary survey, as the predicted expansion of the steel industry in the coming years will probably require more ingot molds.

Thought must also be given to the use of some of the new materials being proposed for ingot molds, such as nodular iron, and how it will be produced in the proposed foundry.

As many ingot mold foundries are part of a steel producing unit, molten iron from the blast furnaces is available, and can be transported to the foundry in suitable equipment to pour the ingot mold and stools.

Where blast furnace metal is not available, suitable cupola melting facilities are required, with all the metal handling and storage equipment.

Following the preliminary survey phase of the foundry project comes the final design phase of the project. Having fairly well determined what equipment and buildings or building changes are required in the preliminary survey, detail designs are made of the buildings, concrete foundations, structural steel, mechanical electrical, ventilation, dust and smoke eliminating equipment, design of any special pieces of equipment needed, employee facilities. These specifications and bills of material are then placed in the hands of the purchasing department for bids from the equipment manufacturers and contractors.

MATERIAL UNLOADING AND STORAGE

As much of the material used in an ingot mold foundry is received in carload lots, ample provision must be made for railroad sidings and storage facilities to handle carloads of pig iron, scrap, coke, and stone for

Figure 6 — Unit is used for preparing molding sand for ingot molds.

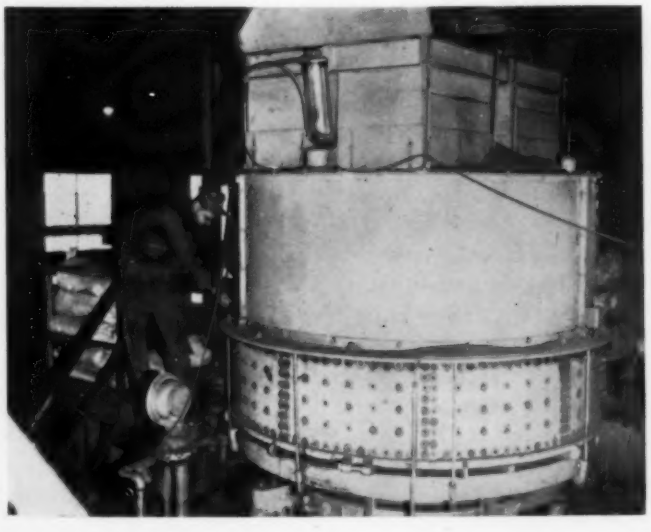


Figure 7 — Unit combines mulling and delivery.

the melting department, plus cars of brick, refractories, alloys, fuel oil, and the many other materials and supplies used in this department. The increasing use of truck transportation for many of the materials and supplies is taken into consideration, and docks and other facilities are laid out for economical handling of truck and trailer, incoming shipments. As the actual cost of a material must include, in addition to the vendor's invoice price, the cost of handling within the plant, materials can frequently be shipped in another form or type, which can be more easily handled, without additional or special handling equipment.

The sand preparation and delivery department of the foundry is another large material using department, with carloads of sand and clay binders (either bagged or in bulk) barrels of wash and corebinder.

Proper design and location of bins and hoppers, with facilities to handle the various materials and supplies, in the way of cranes, bucket elevators, belt conveyors, pneumatic conveyors, lift trucks, etc., make the layout of this phase of the ingot mold operation an important one.

For instance, in the cupola melting operation, if much of the scrap, pig iron and coke can be handled directly from the cars, to the weighing facilities, much economy can be effected. As many as four handlings of these materials have been eliminated by proper layout of the tracks in the melting division. In some large foundry operations, as many as four tracks are spanned by the unloading crane, taking the materials directly from the cars to the cupola charging equipment instead of to stock piles, and then to charging.

Storage of foundry equipment, such as flasks and core arbors is usually provided for in the space under the unloading crane, with transfer cars, etc., to transfer the equipment to working area.

There are two types of space to be provided in any foundry project—working space and storage space. By keeping the working space well cleared of equipment and materials not in use, a much better foundry operation can be had.

Figure 8 — View of load of sand delivered to a coremaker in an ingot mold foundry. By having several barrows, several coremakers can be supplied with sand by one muller.

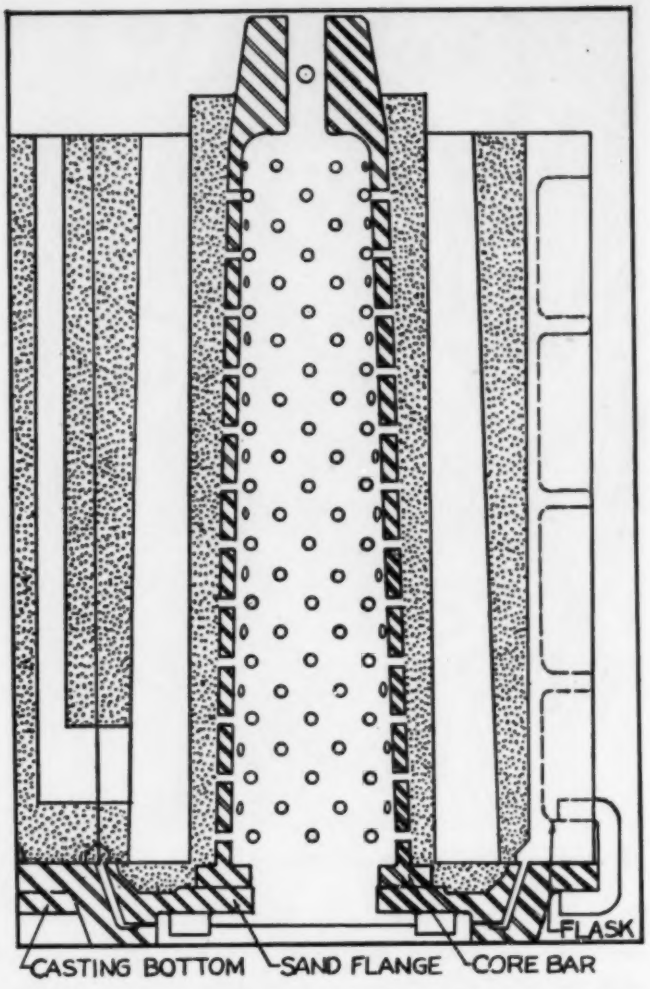


Figure 9 — Cross section of a typical mold for an ingot mold casting shows the various parts that go to make up the mold.

MELTING AND METAL DELIVERY

In an ingot mold foundry, where molten iron from the blast furnace is obtainable, the problems connected with a melting department are greatly reduced. However, in this type of an ingot mold foundry operation, proper facilities for the handling of hot metal, and its storage in the foundry, must be given careful consideration, as many control factors connected with good ingot mold foundry practice, such as pouring temperature, pouring rates, etc., can be upset by a poor layout, in handling the hot metal cars from the blast furnace to the molds in the foundry.

In studying the scope of an ingot mold foundry project, one of the important figures to be computed is the molten metal requirements.

The ideal condition is of course to have the proper amount of metal available to pour each mold as it is completed, but in ingot mold foundries that we have worked on this ideal condition has never been attained.

Therefore the balancing of metal requirements with mold production has to be done very carefully, and facilities for the transportation and storage of molten metal are worked out, and the required facilities determined upon.

The controversial question of blast furnace iron

versus cupola iron for ingot molds has been studied a number of times by our organization over the past years, and in some cases with the assistance of outside authorities, and somehow the blast furnace iron advocates seem to have won most of these controversies.

Where blast furnace iron is used to pour the ingot mold castings, provisions must be made to receive and store the thermo cars used for transporting the iron. Suitable arrangements are required to tilt the thermo car and fill the bottom pour ladle from which the molds are poured.

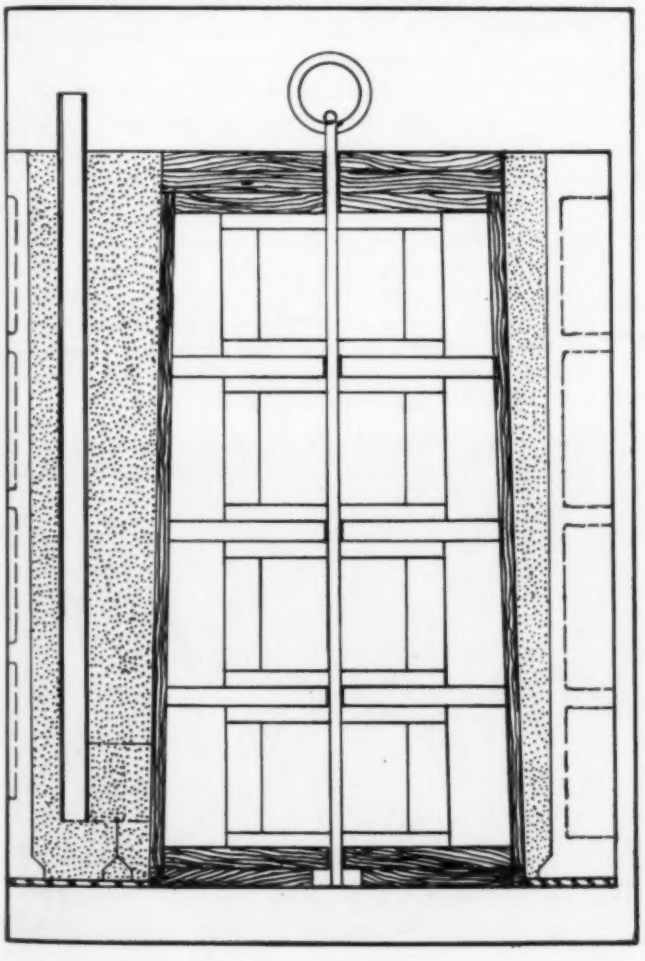
Where blast furnace iron is not available, it is necessary to set up a melting division, and cupolas are the usual means employed, for melting iron, for pouring ingot mold and stool castings.

Cupola melting installations are quite varied, and the usual engineering approach to such an installation is to set up an ideal arrangement from the standpoint of labor, materials used (i.e., scrap and coke consumption) melting rate required, and then design as near an ideal layout as possible.

The melting rate required, determines the size of the cupola, as does such factors, as whether it is best to produce the required amount of metal over a short melting period, which in foundry vernacular is known as a heat shop, or whether this required amount of metal can be used over a long period of time, which in foundry vernacular is known as a continuous pour setup.

The handling of the various materials used in cupola

Figure 10 — Cross section of the mold or cheek shows wood pattern, sprue and locating pins.



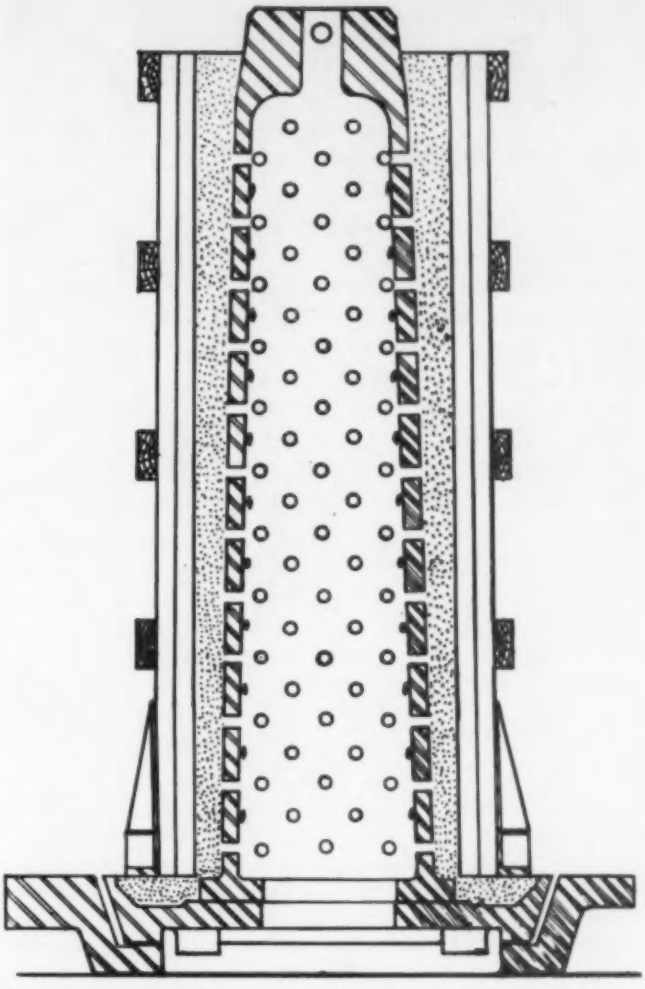


Figure 11 — Cross section of a typical ingot mold core shows the corebox made in four sections and clamped together for ramming and the core bar or core barrel with vents.

melting unit, such as scrap, pig iron, coke, limestone, alloys, etc., can be mechanized to a high degree to eliminate the labor required. Overhead cranes with magnets to handle the scrap and pig iron, storage hoppers for coke and limestone, charge makeup platforms, mechanical cupola chargers of various types, and other mechanical handling devices are employed, to as great an extent as possible. The ideal mechanical charging design is one where two or three men are all that is required, to handle the charging end of the cupola operation.

Facilities for relining the cupola and pouring ladles must be provided in the cupola area, with clay mulling equipment, pneumatic handling devices for patching, and equipment to handle the slag and drop, to the best advantage.

In choosing the cupolas for the melting department, many designs are available. These have hot blast to save fuel, water cooling to save liming material, moisture control on the blast to assist in control of the metal analysis, plus many other items.

As air pollution from the cupola stack must be eliminated in most areas today, the choice of the proper equipment, wet or dry, must be made to eliminate these items from the air. Provisions for handling and disposing of the waste material, either as a separate

unit or part of a plant wide unit must be made.

In a modern cupola setup, there may be refrigerating and chemical equipment ahead of the melting to remove moisture from the air used for melting. The gases coming from the cupola are then sprayed with water to eliminate the smoke and dust in them.

As large volumes of air are used in cupola melting, about as much air as iron, the choice of blowers and design of piping and pressure controls to handle the air are an important item in the engineer's designs.

The mechanization of cupola melting units has made rapid strides in the past few years, and much of the charging labor used in the past has been replaced with mechanical equipment.

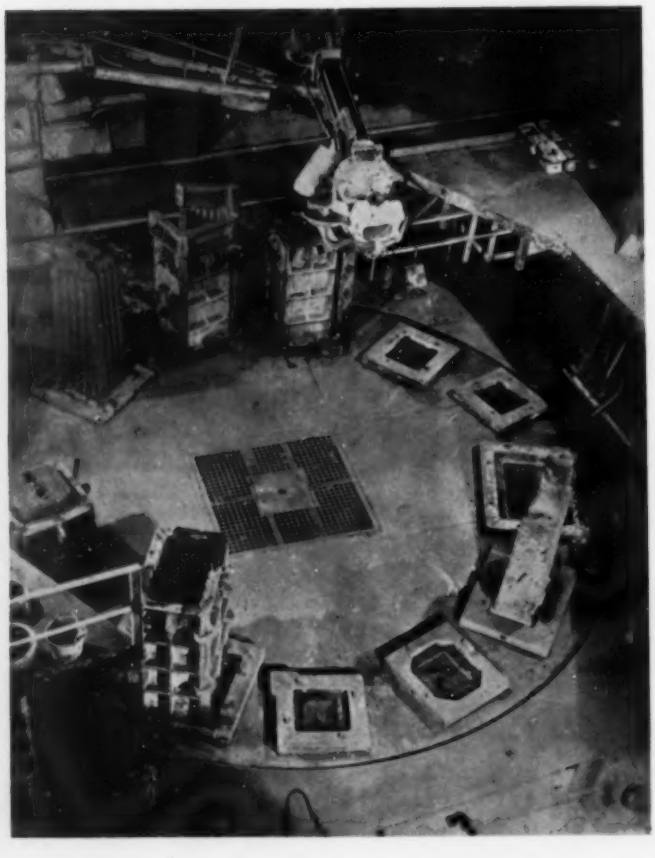
The cupola is charged with a drop bottom bucket of suitable capacity. The bucket is loaded on a power driven transfer car, passing from the metal weigh hopper to the automatically operated coke and limestone weigh hopper, then to a hoisting position, where the bucket is picked up automatically by either a charging crane or hoisting equipment, which raises the bucket to the charging door level, swings the bucket into the cupola, dumps the charge, swings the bucket out of the cupola to the lowering position, and lowers the bucket onto the transfer car, which returns the bucket to its charging position under the metal weigh hopper.

Density of scrap to be used (varies from 90 to 125 lb per cu ft) coke ratio to be used, and amount of slag to be produced, are factors that must be considered by the engineer in the designing cupola facilities.

Charging equipment should have a capacity of 150 per cent of the tonnage to be produced to allow the operator to catch up in case of temporary delay.

Likewise, a number of new cupola designs are now in the picture, to produce special purpose irons from comparatively low cost materials. With the probability of nodular iron entering the ingot mold picture in the future, consideration must be given to this possible step in an ingot mold foundry being designed today.

Figure 12 — This is a 26-ft turntable used for sandslinger ramming cores in one of the large ingot mold foundries. A rammed core is shown, corebox being drawn off a core, a core in the process of being rammed, and locating plates for other cores. This turntable is located with the ramming station in one bay, and the core removal station in another bay, the table assisting in the transfer of the core from the ramming bay to the washing and drying oven loading stations in another adjoining bay.



SAND HANDLING, PREPARATION AND DELIVERY

In the foundry business, sand has been called "the greatest variable." Sand in the foundry may be dirt or an engineered material, depending on management policy. To eliminate as many variables as possible, as well as to reduce handling costs, the sand handling systems in ingot mold foundries have been mechanized to a high degree. Because sand is the great variable in an ingot mold foundry, the success of the operation will depend to a large degree on the behavior of the sand mixture and on the efficiency of the sand preparation. Proper preparation of sand mixture is highly essential. At all points in a sand system, where there is any possibility of the generation of dust, because the sand falls a slight distance, such as the discharge from one belt to another, etc., hoods are provided. These are connected to an exhaust system which carries the dust to a dust collector.

Washed and dried silica sand, Millville gravel, used sand, from the shakeout, bentonite and clay binders, dry binders, seacoal, pitch and water are the ingredients used in most ingot mold foundry sand preparation.

Figure 13 — View of the mold ramming turntable in the same ingot mold foundry as Figure 12 shows the molds being rammed with the slinger in one bay, and delivered by the turntable to the next bay for coating with wash and loading on to drying oven cars. Note the grating in these turntables for removal of the excess sand from the ramming operation.

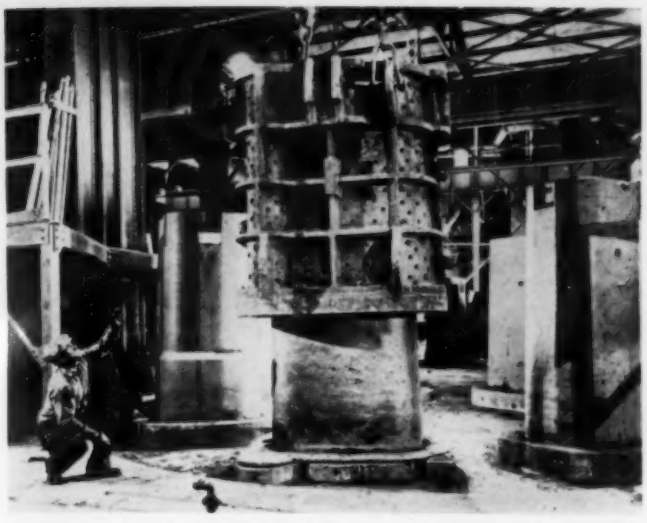


Figure 14 — The flask is lowered on to the pattern. This view shows the location of the turntable in relation to the two foundry bays, the column in the background separates the two foundry bays.

Carbonaceous additives, such as seacoal and pitch, are used primarily for peel, not finish. The proper percentage of these ingredients, are fed into a muller, usually in 2000-lb batches of 26 to 28 cu ft, and mulled for the necessary time to bring the sand to the required specifications. These specifications on the mulled sand include permeability, green compressive strength, baked strength and moisture, and sand testing equipment is provided, either adjacent to the sand preparation equipment, or in the laboratory, to see that the required specifications are maintained within ranges.

Any quick or unaccounted for change in the test curves for the various molding sand properties usually spells trouble, and these changes must be reflected in the molding sand mixtures.

While most of the present day sand tests are made on the sand in the green state, there is an increasing interest in, and development work on the hot properties of sand mixtures. In addition to the mechanical properties, such items as mold-metal interface reactions, metal penetration and heat transfer characteristics of various molding sand mixtures need further evaluation.

The washed and dried sand is stored in hoppers, with suitable measuring devices, either over or adjacent to the muller, and the desired quantities added to each batch. The same is true for the Millville gravel, if used.

SAND STORAGE

The return sand from the shakeout is processed to break and screen out lumps, magnetically separate any iron from the sand, and then put through a cooling operation and stored in hoppers, either over or adjacent to the muller by a system of conveyors. Elimination of dust from this part of the sand system requires adequate equipment.

The bentonite, clay, dry binders, pitch and seacoal, are added to the batch in the muller, either in dry form or as a slurry with the water slurries. Provision for delivery and storage of the binders, if used dry,

Figure 15 — Closeup view of the sandslinger shows the operator seated over the ramming head so that he can see the slinger is properly throwing the sand. Also seen are the feeder belt from the sand supply, which is usually a pan feeder, to supply sand at the proper rate to the slinger head.

Figure 16 — A core is being lifted by the crane from the finishing and washing station to the drying oven. Wash is sprayed on the cores and molds with low pressure air, 15 to 20 psi.

must be made, and these are designed to suit the requirements. Where large volumes are used conveyors of various types are used, but if the requirements are low, then it is usual to use a lift truck to deliver a day's supply of the binders to the muller area. If the slurry system is used, the slurry is prepared at a point away from the muller and pumped to a tank above the muller, from which tank, the required amount of slurry is added to each batch in the muller. Slurry

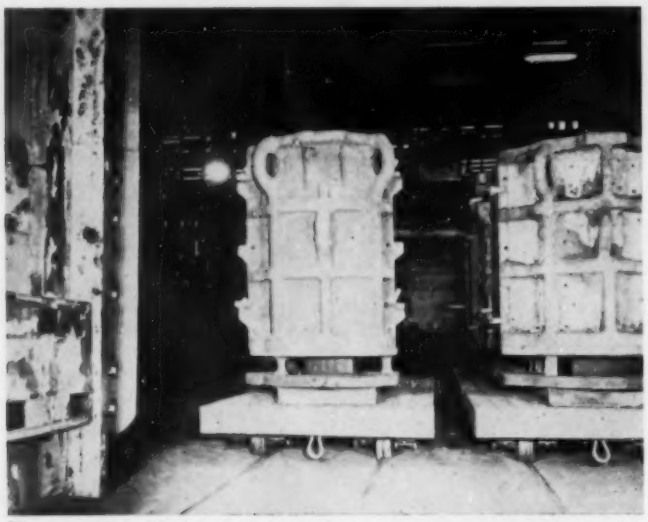


Figure 17 — Mold and core are on oven car ready to be pulled into the oven.

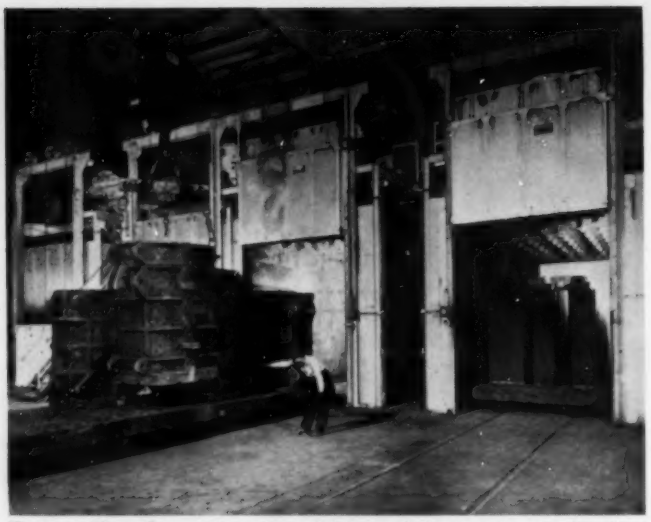


Figure 18 — Some ingot mold foundries prefer to dry the molds and cores in separate ovens as shown.

systems are said to save from 10 to 33 per cent of bond necessary, are dust free, and reduce mulling time. The slurry setup can also be used to prepare the mold wash which is used on the molds and cores, and which can be pumped to point used.

The usual design of a sand preparation unit requires a fairly high building, and in the layout is frequently set to one side of the foundry where there is no crane interference. A penthouse is often used to house this equipment.

For handling the varied types of materials used in the sand preparation and delivery unit, a wide range of conveying equipment is available, belt conveyors, bucket elevators, pneumatic conveyors, and a variety of open and closed type conveyors to handle the dry materials especially. A material such as washed and dried sand runs like water, and will spill and cause cleanup problems if not properly handled.

A special cone bottom for circular silos has been developed which will minimize, and often eliminate the segregation in different grain sizes, which occurs when dry, washed sand is withdrawn from a storage bin. It consists of a specially designed orifice in the base of the silo, through which the sand flows upon discharge.

The segregation which occurs when the silo is loaded is reversed, upon discharge through this orifice, providing uniformity, classified sand. A special double cone is provided below the orifice to permit its proper functioning. With this device, unsegregated sand can be withdrawn in either a continuous flow, or in batches.

The same operation applies to the bagged materials such as bentonite, pitch and seacoal, and the handling of these materials requires properly designed storage, and handling equipment.

The storage bins and sand hoppers should be of a design, which will permit proper feeding to the discharge gates effectively, and not just through the center area of the hopper. Vibrators, bin rappers and such auxiliary equipment may be required to make sand hoppers feed properly, and prevent hanging up on the sides and corners.

Mulled sand from the speedmullor is delivered to plate feed hoppers at the mold ramming station.

As the shakeout sand is usually quite hot, the speedmullor is provided with cooling equipment, to cool the sand while mulling, and thus eliminates the hot sand problem which is a source of trouble in the molding operation. A maximum sand temperature of around 112 F, is best for molding.

Core sand is required for the cores, used for cover cores, and for bottle top molds made in some ingot mold foundries.

If the quantity of core sand required is small, then a combined mulling and delivery unit is used. By having three or four of these, a good quantity of core sand can be provided.

MOLDING

The molding of an ingot mold casting requires a mold of two parts, the cheek and a core.

The majority of ingot molds made today, are rammed on sandslingers. This type of ramming has almost entirely replaced the hand ramming with pneumatic rammers, and large jolt machines formerly used for ramming ingot molds and cores. With the sandslinger, hard rammed molds and cores are obtained even at depths of several feet, and actually the bottom of the core is often over 12 ft from the sandslinger head, and the slinger ramming still does the job.

The thickness of the wall of sand used, either between the pattern and flask, or between the wall of the corebox and the core barrel, is one of the critical dimensions in the use of sand slingers, for ramming both molds and cores. The wad of sand, thrown by the sandslingers cup, is about 5 in. long. To try and put this wad of sand 5 in. long, into a 3-in. opening, presents some ramming difficulties. It also adds a factor of wear on both the patterns and coreboxes.

So sandslinger ramming, which uses one man on the ramming job, instead of the three or four required with pneumatic rammers, may mean properly designed flasks and arbors to permit good slinger ramming.

The molding job is usually divided into two operations at two adjacent locations. The coreboxes and arbors which form the inside of the ingot mold casting,

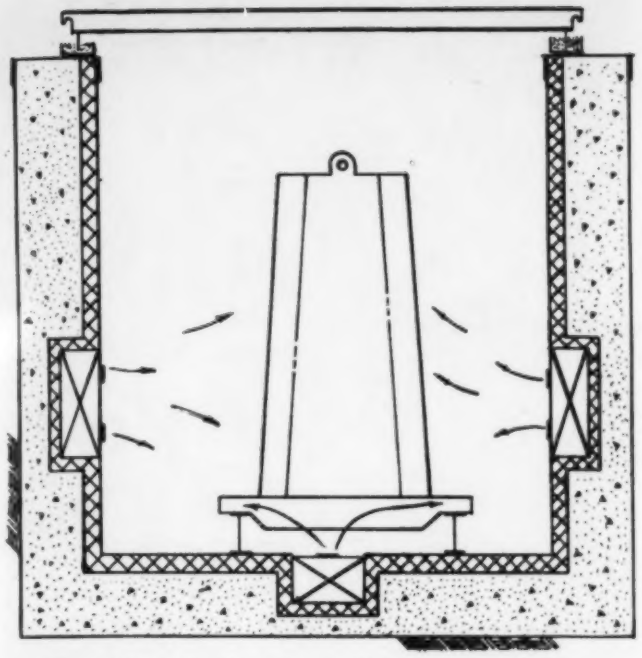


Figure 19 — Section shows pit type oven for cores.

are set up for ramming at one location, while the pattern, which forms the outside of the ingot mold casting, is set up in another location. Locating pins are used to set the corebox arbor and the pattern in the proper positions, so that they will match up to form a complete mold for the casting.

Flasks for molds, coreboxes, patterns for molds and core barrels are usually made of cast iron or cast steel for the larger ingot mold foundry operations. Core boxes are usually made in four sections, with machined mitred corners, and held together with wedge clamps. In one of the large ingot mold foundries that recently went into operation, the molds and cores are rammed on a 25-ft electrically operated turntable of heavy construction.

Completed sand molds and cores are handled by overhead crane to an area where they are sprayed with mold wash or blacking.

MOLD AND CORE BAKING

There are two basic methods of drying ingot molds and cores. The latest type of equipment involves the use of specially designed car type ovens for the drying of assembled molds and cores.

Since the first of these new ingot mold ovens has been in operation, steaming molds have been completely eliminated, and ingot mold castings have excellent quality. In addition, accidents to equipment and workers have been reduced, maintenance costs lowered, and equipment turnover vastly improved.

The advantage claimed for the ovens of the latest design are as follows:

1. Cheeks and cores can be dried as an assembly. This reduces the amount of oven space required by one-half and also saves handling time.
2. Latest design ingot mold ovens dry the molds in one-third to one-fourth the length of time required by old style ovens. This means a fuel saving of approximately 75 per cent.

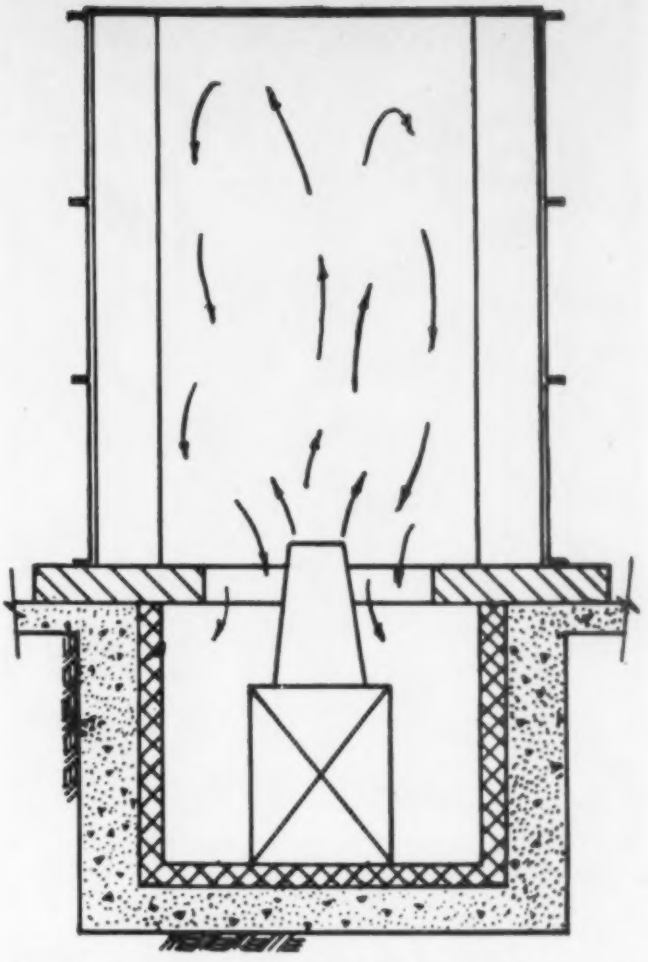


Figure 20 — Section shows mold drying tunnel as used in some ingot mold foundries.

3. The short drying time of ingot mold ovens permits flask equipment to be used every day instead of once every two or three days. Accordingly, production is increased without the expense of additional flask equipment.
4. These ingot mold ovens completely eliminate all the guesswork of old style ovens. The heat is uniformly distributed and accordingly all work is evenly dried, and the rate of drying is the same

Figure 21 — View shows pit type furnace for drying cores.

Figure 22 — Cores are set up along pouring platform and mold is being closed.

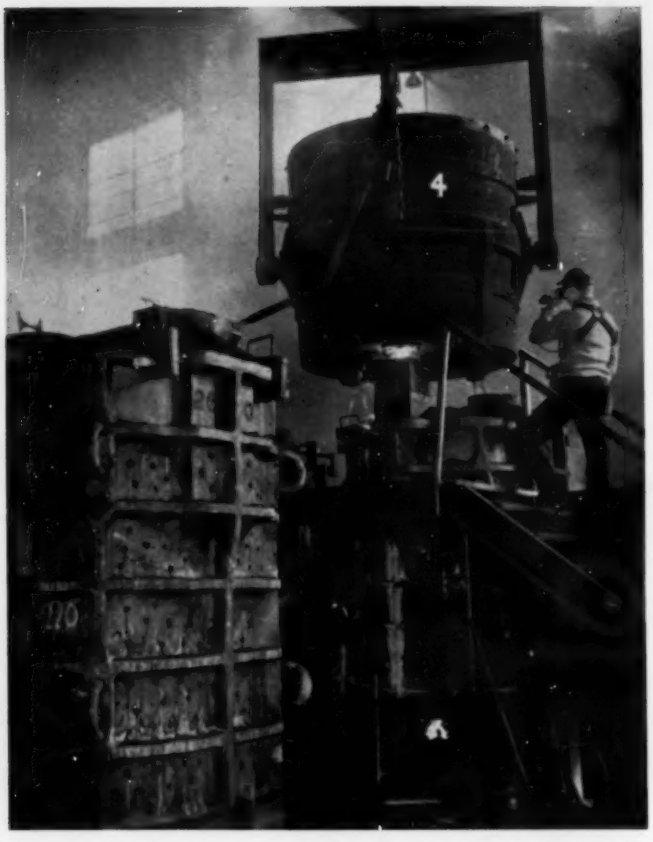


Figure 23 -- Bottom pour ladle is pouring ingot molds.

for all sand surfaces. In other words, light and heavy sections, or small and large molds can be dried in the same oven regardless of location in the oven.

5. In ingot mold foundries, maintenance of the cars and track systems in old style ovens has been a serious problem and a major expense. The cars and tracks would be distorted and caused molds to fall over, damaging the ovens and injuring the workers.

   In these ingot mold ovens, however, the heat is applied only to the molds. This substantially reduces maintenance costs and eliminates the hazard of molds tipping over. Because the cars run smoothly, the molds are not subjected to distortion. Therefore less green strength is required and one can use lower cost sand mixes.
6. The most important advantage of all, however, is proper drying of the molds. A properly dried mold does not steam and therefore all of the defects caused by steaming are eliminated. Good ingot molds, free from defects, produce better ingots and give longer service life.
7. Cleaning of the ingot castings is substantially reduced and simplified because properly dried molds help eliminate sand inclusions, burn-ins, etc.
8. Before modern ingot mold ovens were introduced to the industry, a high loss of ingot molds due to improper drying was considered normal. By proper drying of all molds, latest design ingot mold ovens have eliminated this loss. This means a 33⅓ per cent production increase over and above the increase brought about by faster drying and improved equipment turnover.

A second method used for drying molds and cores is called the pit type oven. In this method, the molds and cores are dried separately and then assembled before pouring.

The cores are placed in an insulated enclosure or pit by an overhead crane, and insulated roof panels placed over them to seal off the compartments. A recirculating air heating system then supplies high velocity heated air through a duct system to dry the cores. Any number of cores can be placed in the pit.

The molds are dried by placing them over drying

Figure 24 — Shaking out operation on ingot molds shows flask being lifted off. Grating is over the shakeout sand return conveyor.

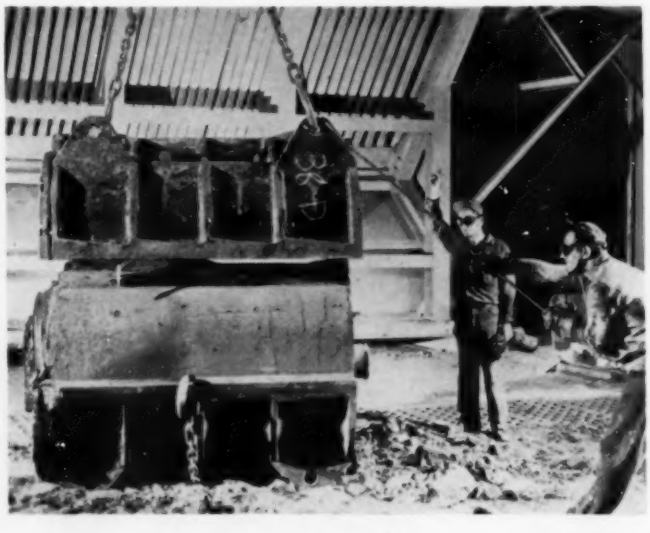


Figure 25 — Shakeout operation differs where the core barrel is attached to the bottom plate.

Figure 26 — High pressure water jets confine dust over a heavy casting shakeout in large casting foundry.

stations, located in a shallow pit or trench. A recirculating air heating system then supplies heated air through high velocity nozzles, to dry the molds. Again any number of molds can be dried by one system, although each mold requires a separate drying station. In some cases, the air heating system has been mounted on a nearby wall to conserve floor space.

As a general rule, the pit type of installation is used for lower rates of production, and where existing plant facilities precludes the possibility of drying the core and mold as an assembly. It has proven very successful in several steel plant ingot mold operations.

The preceding gives a general picture of ingot mold dryer installations by the two methods generally used.

Each has its inherent advantages, and the engineer making an ingot mold foundry layout can choose one or the other, depending on requirements and conditions.

The two requirements of the mold drying are: (1) elimination of the moisture, and (2) oxidation of the bonding materials must be kept in mind by the engineer.

MOLD CLOSING

The first operation in closing the molds for pouring is to place the casting bottom in a level position alongside the pouring platform. The casting bottom has a depression into which the core barrel fits, this being a male and female joint. The core is then lowered into the casting bottom, and the joint of the mold filled with molding sand, which is carefully leveled to prevent metal from entering the joint. The mold is then lowered into position over the core and clamped securely to the bottom. After clamping and placing of a pouring cup over the sprue, the mold is ready for pouring.

POURING AND COOLING

The pouring of ingot mold castings and stools is usually handled by bottom pour ladles. The ladles are filled at a filling station, either from the hot metal car, or from a holding ladle, in front of the cupola.

Figure 27 — Cleaning operations on ingot molds.

Figure 28 — Shipping facilities must provide for rail and trailer shipments.

The ladleman handles the pouring lever from a pouring platform.

The elevated pouring platform, is designed to take care of spills, leaky stoppers, runouts and other hazards, that enter into pouring hot metal into molds.

It is a rigid structure to stand bumps from crane

hookers to provide good footing, and still be protected from the hazards of leaky stoppers and runouts. The pouring platform, usually about 6 to 7 ft wide, is located so that the craneman has a good view of the operations he is required to perform in both closing molds and in pouring.

As much of the smoke and heat in an ingot mold foundry operation is in this area, ample provisions for ventilation are required above the pouring platform. Curtain walls are used to confine the smoke and heat, and ample ventilators are used over this area.

In some ingot mold foundry operations, the cheek of the mold is lifted off the pouring bottom, while either at the pouring station or in the cooling area, and the cheek is rested on blocks about 10 in. high. This allows air to pass through the mold, and creates a chimney effect, which aids the cooling of the casting.

However, this chimney effect creates a smoke and dust problem in this area that is difficult to combat.

From the pouring area, the molds are sometimes moved by crane to the cooling area, or if a cooling area is not used, then directly to the shakeout area.

SHAKEOUT

Adjacent to the cooling area, the ingot mold casting is removed from its mold. The mold is carefully tipped to a horizontal position on to a shakeout grating.

Clamps are knocked off, and the top half of the flask is lifted off and placed on a car. The other section of the flask is rolled over, dumping the casting and sand on to the shakeout grid, and that half flask is placed on a transfer car. Rolling the flask over removes most of the sand from the exterior of the casting, and also loosens the core so that the core barrel can be readily removed from the casting and placed on the transfer car.

In some of the ingot mold foundries, the flask and casting are lifted off the core, leaving the core bar and bottom standing.

Mechanical shakeouts have been given consideration for shaking out ingot mold castings and will probably be used in future ingot mold foundries.

In order to confine the dust and gases rising from the mechanical shakeout, a water curtain device has been considered.

This device offers the foundryman a means of obtaining protection over a shakeout which will permit him to return air so cleaned to the foundry, without a dust collector and without evacuating to the outside. This should make an appreciable saving in heat loss and will reduce the total volume of air moved from the foundry to the outside. It should have a significant effect on air pollution problems.

Some of the foundries using this type of equipment have found that it has been quite effective in removing smoke and dust from surrounding areas.

VENTILATION, SMOKE AND DUST ELIMINATION

For many years, foundries have not been considered the most pleasant places to work.

Foundry processes are the source of:

1. Dust, fumes and gases.
2. Noises.
3. Heat.
4. Radiation.

The undesirable environment of the foundry is in relation to the intensity, and duration of exposure, to these influences.

Ventilation systems are installed in foundries:

1. To remove or dilute air contaminates, or excessive heat, to a safe concentration.
2. To improve employee morale.
3. To provide a more desirable place to work.
4. To reduce maintenance.
5. To improve housekeeping.

Compliance with regulating codes in the minimum requirement for a ventilation system, and how much this minimum should be exceeded is a matter of company preference.

General ventilation, supplemented by local hooded exhaust systems in the immediate area of contamination, are now being used in ingot mold foundries.

For general ventilation, roof ventilators and exhaust fans in walls or windows are used. In some areas, curtains are dropped to the bottom chord of the roof trusses, and give satisfactory results. Short circuits of the air must be avoided in the upper building areas, or air movement at the lower or floor levels, will be negligible.

The dust, smoke and fumes picked up by the local hooded exhaust systems around the shakeout area, sand systems, molding and core making and baking, melting and pouring area, ladle drying, cleaning operations and welding operations are drawn into collectors.

The wet type dust collectors are proving quite popular in ingot mold foundries, there being three or four types of wet collectors for the engineer to choose from. Wet type collectors have no fire hazard, and no health hazard from handling dust, and can operate continuously.

An adequate scheduled maintenance program for foundry ventilation and dust collection system will pay for itself by reducing production time losses and costly major repairs.

The engineer, in this design, should allow for the eventual removal of parts which may wear out, or become damaged by cranes or other equipment. Extra heavy construction should be used, on parts exposed to wear or mechanical abuse, and adequate service catwalks, platforms and ladders should be installed for worker's safety and convenient access to equipment and maintenance.

Many large casting producers have improved the dust condition on their floors by the use of wet water sprinkling equipment.

CLEANING AND MACHINING

The interior of an ingot mold casting is thoroughly cleaned of all sand, scabs and burnt in sand, by chipping with pneumatic hammers and grinding with hand grinders. Molds must be positioned for cleaning air, electric outlets provided, and cleanup arranged.

If any welding of defective areas is required, the

welding is done in a welding booth in the cleaning area.

The cleaning area is serviced by overhead cranes, which positions the ingot mold castings for the various chipping, grinding, welding, and machining operations.

As a percentage of the ingot mold castings require a machining operation to level the bottom of the mold casting, equipment must be provided to perform this operation and service the machines, remove the chips, and lubricate the machine and tools.

Ample cleaning facilities should be provided, as, in many ingot mold foundries, the cleaning is one of the production bottle necks. Facilities for servicing the pneumatic chippers, hand grinders, and extension lights required, must be provided in the cleaning room.

The effect of good sand practice in the making of the molds and especially the cores is very noticeable in its effect on the amount of work required in the cleaning room.

STORAGE AND SHIPMENT OF INGOT MOLD CASTINGS

Following the cleaning operation, it is sometimes the practice to tar the interior of the ingot mold to protect the mold surface until the mold goes into service. If this practice is used, proper facilities must be provided in the layout of the cleaning area, to do the tarring of the molds.

Storage and shipment facilities are required, necessitating weighing and loading equipment.

LABORATORY FACILITIES

A laboratory is a necessity in an ingot mold foundry, and facilities must be provided for preparation of metal samples and analysis as well as facilities for testing sand and checking other materials used in the foundry operation.

AUXILIARY DEPARTMENTS AND EMPLOYEE FACILITIES

Pattern making and repair facilities must be provided with the required woodworking and metalworking tools. Pattern storage buildings should be adjacent to the pattern shop, with necessary handling equipment for the patterns and coreboxes.

A good size repair area is required to maintain the mechanical and electrical equipment used in the foundry, and with suitable tools, hoists, cranes, storage for spare parts, and machining and welding facilities for handling maintenance jobs.

Stockrooms for handling foundry supplies and tools, with proper facilities for receiving and dispensing of supplies, as well as storage are required.

Shop offices are another requirement, with facilities for supervisors and clerical help.

Employee facilities in the form of toilets, locker rooms, shower rooms, lunch rooms and parking areas must be provided.

If the ingot mold foundry is a new plant, the proper site improvements must be one of the early steps taken care of.

SUMMARY

To assure a well coordinated job, and a modern efficient ingot mold foundry, it is well to place the engineering in the hands of experienced personnel, to cover all phases of the engineering and construction, and maintain a continuity of experienced supervision.

Proper cooperation must be maintained, between the engineer and the foundry operating staff, to assure success of a new or revamped ingot mold foundry. The changeover to new and mechanized operations is never easy for either—but after all the difficulties in training men to the mechanized operation are overcome—the results are very pleasant.

DISCUSSION

PRESENTED BY

G. A. DORNIN, JR., Chief Engineer, Shenango-Penn Mold Co., Shenango, Pa.

R. R. ASHMAN, Superintendent of Ingot Mold Foundry, Bethlehem Steel Co., Bethlehem, Pa.

GLENN W. MERREFIELD, Foundry Engineer, Giffels and Vallet, Inc., Detroit, Mich.

George A. Dornin, Jr.: Since we produce molds and stools for pretty much the entire steel industry, we must, of course, meet its extremely varied requirements as to both size and type. We regularly make some 40 different types of molds and currently have about 200 different designs in production. We have, during the life of the company, made molds of over 4,000 different designs, ranging in size from 2¼ x 2¼ x 11 in. (weighing 150 lb) to 63 x 63 x 143 in. (weighing 128,000 lb).

Naturally this extreme range of sizes and types poses many problems as to patterns, pattern storage and equipment (i.e. flasks, core bars, etc.) and it also means numerous production and layout problems. For instance, the making of an occasional very large forging mold calls for entirely different treatment from that required in the making small or medium sized molds at high production rates.

Our product mix breaks down roughly into four groups of castings:

1. *Production molds* (4,000 lb to 60,000 lb and averaging about 18,000 lb). These are usually ordered in reasonably large quantities, from 1 to 20 molds per day of each design.
2. *Very large molds* (mostly for forging ingots) usually ordered only one or two at a time.
3. *Small molds* (under 4,000 lb).
4. *Stools.*

In our attempts to get the most efficient p oduction setup, we have considered numerous plans and actually tried five different ones involving three plants. We have now pretty much settled on one which we feel is working out very well.

The production molds are made in both our Sharpsville and Neville Island plants, the layouts being very similar. In each plant the ramming and drying is done in one bay and the dried cores and cheeks are transferred to an adjacent bay (somewhat longer) where

the molds are setup, cast, shaken out, chipped, machined and shipped.

The very large molds are all made at Sharpsville in a separate department, the largest being rammed in "holes" rather than flasks. Here all operations take place in a single bay. One end of this building is given over to the making of stools and foundry equipment.

All small molds are made at the Neville Island plant, again a separate department with its own foremen and personnel being utilized for this work. The opposite end of this building is used for making stools and foundry equipment.

R. R. Ashman: Mr. Merrefield presented an excellent paper on the methods and equipment which must be considered before a new ingot mold foundry construction program can be properly engineered.

Although an ingot mold is one of the simplest castings made by the foundry industry, it seems that everybody has a different method or practice of manufacture.

It is difficult to make a prepared discussion due to the variations of manufacturing methods employed and the great number of different mold sizes and designs used in the steel industry, especially since the geographic location of the foundry has such great bearing on the manufacturing methods to be used.

The Bethlehem Steel Co.'s ingot mold foundry produces molds ranging in weights from 3500 to 140,000 lb; 250 to 300 patterns of various sizes and designs are used, since molds are supplied to a number of independent Eastern seaboard steel companies in addition to those produced for the company's own use.

Basic ingot mold manufacturing practice is substantially uniform throughout the industry as far as the fundamental process stages are concerned; however, methods of process application vary widely from plant to plant due to local conditions of material availability, available space, procurement situation, individual process evolution, and management consideratons. Examples of process variations from Bethlehem practice are noted in the following as an indication of differences encountered.

Sand preparation practice at Bethlehem differs widely from usual practices since the proximity of the New Jersey gravel banks makes a naturally bonded sand readily accessible. Sand made from this material is prepared in low-speed mixers with sand strengths developed to levels double that of semi-synthetically bonded sands prepared in speed mullers in other plants.

Molding practices range from the combined nonperforated core barrels and bottoms as-rammed, used at Bethlehem, to the assembly of individually rammed cores and bottoms used elsewhere in the industry. Bethlehem molds are nearly 100 per cent machine rammed, whereas some other shops ram by hand-operated pneumatic tools. Molds in some plants are rammed on molding floors or turntables while we have developed a method of pit ramming. Mold coating applications vary from our hand-dipper method to spray methods. Wooden core boxes are used for molding, in contrast to the metal-box practice of other plants.

Mold drying practice at Bethlehem is effected in recirculating ovens in a relatively long cycle at low temperature, while other practices involve non-recirculating oven design operating in shorter cycles at higher temperatures. Here molds are dried with components assembled but blocked apart for circulation, while other practices often involve separate drying of mold components.

Casting operations vary according to plant arrangements and range from the Bethlehem practice of using a hot metal mixer to ladle filling direct from blast furnace railroad ladles and cupolas. These practices affect casting temperatures which range from random values to controlled ranges achieved through use of a hot metal mixer.

Core barrel extraction methods range from our pneumatic pile hammer extraction, two to six hours after pouring, to crane or machine extraction following complete mold cooling.

Flask knockout at Bethlehem is effected by crane-swing against bumping blocks, whereas other plants disassemble dowelled flasks to remove castings individually.

Handling practice at Bethlehem is simplified through the development of standardized wire-rope cable slings in contrast with the use of lifting chains in most other shops.

From what has been mentioned, it is readily appreciated what difficult tasks an engineer faces when designing a new ingot mold shop.

Glenn W. Merrefield: Each ingot mold foundry has to be designed to fit a number of conditions—area available, metal, molding materials and a number of other factors. As engineers of foundry facilities, it is necessary for us to take all these conditions into consideration, to design an ingot mold foundry, to produce molds economically. We are very appreciative of the comments of Messrs. Ashman and Dornin, and also of the information given me by other ingot mold foundry operators, both captive and commercial.

WANTED!

There is a constant demand for copies of "The Modern Strip Mill," published by the Association of Iron and Steel Engineers.

If your copy is not in use please get in touch with us.

ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

By I. W. EVANS, Chief Welding Engineer, The Morgan Engineering Co., Alliance, Ohio

Welded Structures in cranes and mill equipment

. . . . welding is being applied more and more to equipment going into the steel plant . . . . such designs cannot be taken as copies of castings; joints must be calculated and weld sizes established by the designer and not by the welder or fitter . . . . greatly expanded applications are still to come . . . .

▲ WELDING has grown from a maintenance tool used in the event of a breakdown or emergency repair to an established method of joining metals—ferrous, non-ferrous or any combinations thereof. Today it is now difficult to name any fabricated product that does not utilize the welding processes.

The reasons for this trend are numerous, but the majority can be covered by the following groupings: product availability, product control or quality control, scheduling and deliveries, versatility from the standpoint of lending itself to designers' requirements, ease of utilizing dissimilar or composite materials, and last but certainly not least, are the economies that can be effected both to the customer and the manufacturer.

A brief explanation will clarify the aforementioned groupings. Product availability would encompass such items as changes in design and alterations as determined by service requirements which can be modified by merely utilizing cutting equipment, welding equipment, and in most cases plate, thereby eliminating the possibility of discarding a machine element or expensive pattern changes plus decreasing to a minimum the time element.

Product quality, quality control, scheduling and deliveries can be explained together as they are interdependent. By eliminating castings, where they have been troublesome, and using plates and billets in such components as stripper barrels (Figure 1), ram casings (Figure 2), hoist drums (Figure 3), stripper links, bearing blocks, gears (Figure 4), sheaves, large housings, gear boxes and guide frames, one can eliminate the questionability of soundness and have complete control over the product as it goes through the manufacturing stages.

Regarding scheduling and deliveries, a situation that happened recently will serve as an illustration. A cast hoisting drum requiring 12 weeks delivery by the foundry, and three to four weeks machining in the shop, was found to be defective when the finishing machine cut was made. The drum was scrapped and another 15 weeks were required for delivery. This drum was later made into a weldment and was produced in eight weeks total time.

Versatility for the designer entails the advantages of utilizing and combining structural shapes with plates, also varying thicknesses where needed, without depending upon the flow of materials from one section to another, which also enables the reduction of excess weight where it may be critical. In addition, closer tolerances can be achieved which lessen the required machining time.

Ease of utilizing dissimilar metals is reasonably self-explanatory, but illustrations such as the joining of materials like stainless steel to steel, copper-nickel alloys to stainless steel and steel, cladding parts for wear where the core must be soft and the surface extremely abrasive resistant, are numerous.

All the aforementioned reasons effect economies by

Figure 1 — Cast stripper barrel halves of 4130 modified alloy are being submerged arc welded.

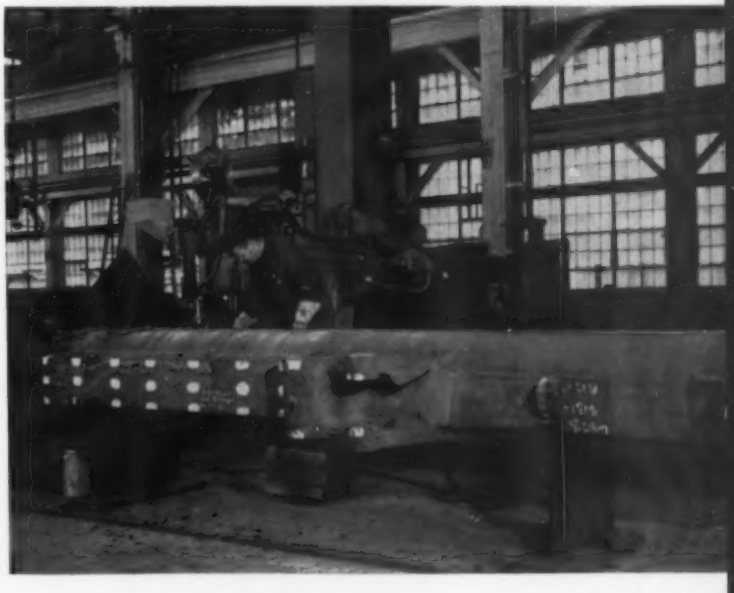


Figure 2 — Ram casing for 200-ton stripper was converted from casting to weldment utilizing submerged arc welding throughout.

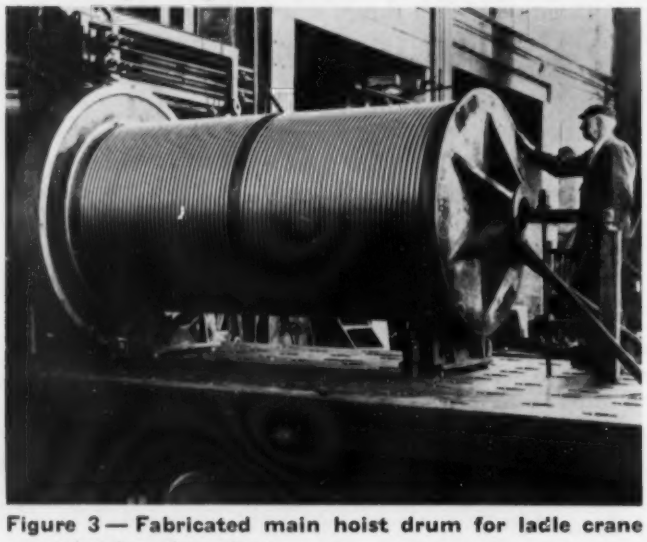


Figure 3 — Fabricated main hoist drum for ladle crane takes less shop time.

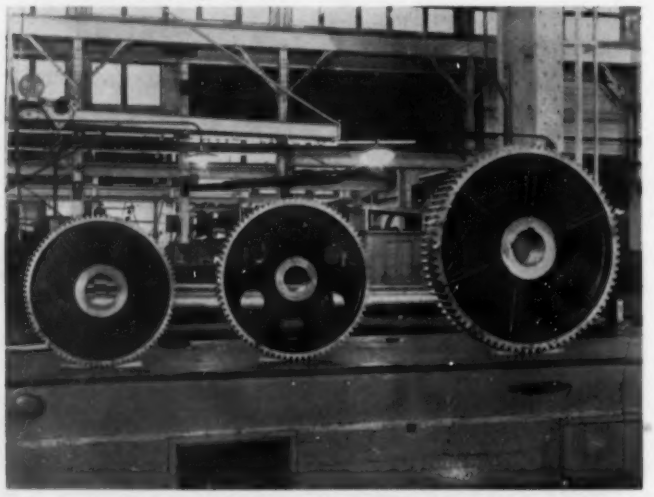


Figure 4 — These three gears are typical of those used in a beam straightening machine which utilized all fabricated gears.

reducing spoilage, increasing production, improving deliveries and creating greater customer satisfaction.

In recent years much has been done in developing electrodes, semi-automatic and automatic processes to the point where quality can be assured. In effect, welding has progressed from a skill to a science, so that materials having high strength, severe shock resistance, and other desirable properties but heretofore considered difficult to fabricate, are now being welded and used in such services as aircraft landing gear, manipulator heads, beam straighteners, etc., where the quality of the weld cannot be in doubt.

The electrode and welding power supply manufacturers have had a decided influence upon the overall growth and acceptance of welded products and certainly deserve a vote of thanks.

Some of the more recent contributions are the constant voltage power supplies that permit controlled preset voltage, thereby assuring high quality weld deposits that are consistently reproducible. The sigma, aircomatic and filler arc processes now enable such metals as aluminum, magnesium, bronze, inconel, monel, and the new group of stainless steels that are corrosion resistant at elevated temperatures, to be readily welded. The new electrodes such as the group commonly known as iron powder type electrodes that have strengths of 80,000 to 90,000 psi ultimate tensile strength, and 70,000 to 80,000 psi yield strength, temporarily classified by the American Welding Society as AWS-E-6024, have also aided in minimizing the operator variable. This is attributed to their higher physical and mechanical properties, plus their operating characteristics, which reduced both the skill requirements and size of weld needed to accomplish good joints of high strength.

The aforementioned developments are being utilized within our organization in such applications as the sigma process for hard surfacing, build-ups and nonferrous metals; constant potential power supplies in conjunction with the submerged arc process, automatic, semi-automatic and the sigma process; and the iron powder electrodes are standard for all manual welding of steel.

A subject that has been controversial for some time is that of riveted girders versus welded girders:

The writer would like to present some of the arguments or objections that have been made against welded girders and then take each objection and present the writer's experiences, opinions, and views.

One common objection is said to be the variable human element (the welder). Within our organization we utilize submerged arc welding for all girders, using a universal ram type machine with dual heads and tracing devices (Figures 5 and 6). The machine has a travel range of 110 ft in length, 15 ft in width, and 17 ft in height. It is capable of traveling speeds up to 120 in. per min. It is unique in that it has two heads that float both horizontally and vertically and will traverse curves such as those encountered in a fish belly type girder. This unit is also used for welding dual flanges, wearing strips, and both ends of hoist drums simultaneously, again eliminating the operator variable.

As an afterthought, what is more variable than the temperature of the rivet calculated by the heater's judgment using his eye as an optical pyrometer?

Another objection is that welded girders do not react favorably where heat or where severe service requirements are encountered, such as soaking pit cranes, ladle cranes, etc. For some years now these cranes have had welded trolleys, end trucks, equalizers,

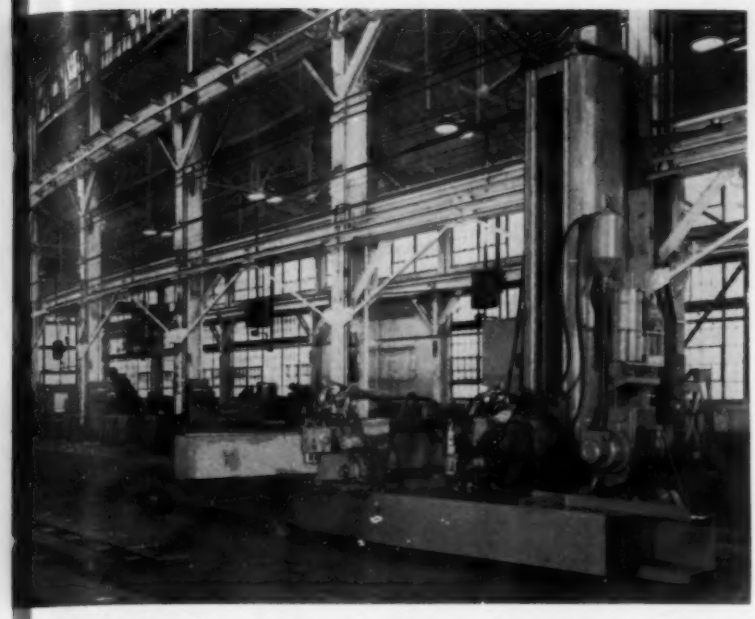


Figure 5 — Overall view shows the universal ram type machine automatically welding a girder.

Figure 6 — The automatic girder welder has dual tracing heads that float both vertically and horizontally.

lifting beams, end carriages, etc., and have proved very successful in this type of service. In addition, a number of ladle cranes, pit cranes, etc., with welded girders have been in operation for some time and are also doing very well. A riveted structure has a discontinuity wherever there is a rivet and therefore creates a very poor expansion and contraction condition with an uneven stress distribution. A welded girder has uniform plate of the same thickness which lends itself to an ideal uniform heat transfer condition and a uniform stress distribution.

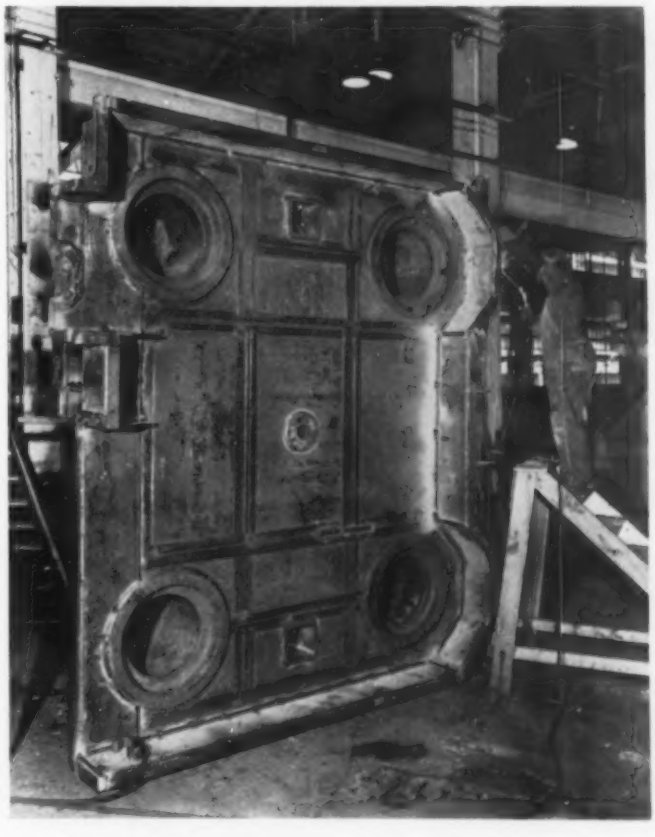
The following are some of the writer's objections to riveted girders based on his experiences and factual information. Normally a riveted girder will be heavier by 25 per cent or more than a welded girder which causes a pyramiding effect in that the additional weight requires larger motors, larger shafting, larger couplings, larger wheels, larger gearing, etc., all due to a dead load that adds nothing to the performance except parasitic weight.

Repairs are made difficult because of poor accessibility, excessive down time, and excessive repair cost. An example of this would be the repair of loose rivets on web plates. The normal procedure would be to remove the top cover plates so that the rivets can be bucked. Upon examination of the labor this operation alone entails, one can see why it is so costly both in excessive downtime reflected by production losses, and the cost of the repairs themselves. These operations encompass removing all the rivets attaching the cover plates to the web and any adjoining parts, and then riveting these same sections together again after the repairs are made. This might also involve additional labor such as redrilling some roles and using larger rivets when the holes are elongated.

However, there are some alternatives, such as ringing the rivets with weld or cutting holes in the top cover plate, bucking the loose rivets, and then welding the pieces back in place. These alternatives all entail using welding which in itself becomes a paradox, since the welded girders were not considered satisfactory to start with, yet welding is used to repair them in locations which apparently are the points of highest stress.

The writer has had numerous requests from customers for procedures to repair riveted girders that have had cracks propagating from one rivet to another, also through adjoining plates, and in most cases this involves repairs by welding. When this is done, there is a very good possibility that the rivets alongside the repairs will be loosened by the heat and before long

Figure 7 — Rear of the main housing for the beam straightening machine in which all the main welds were made by the submerged arc process.



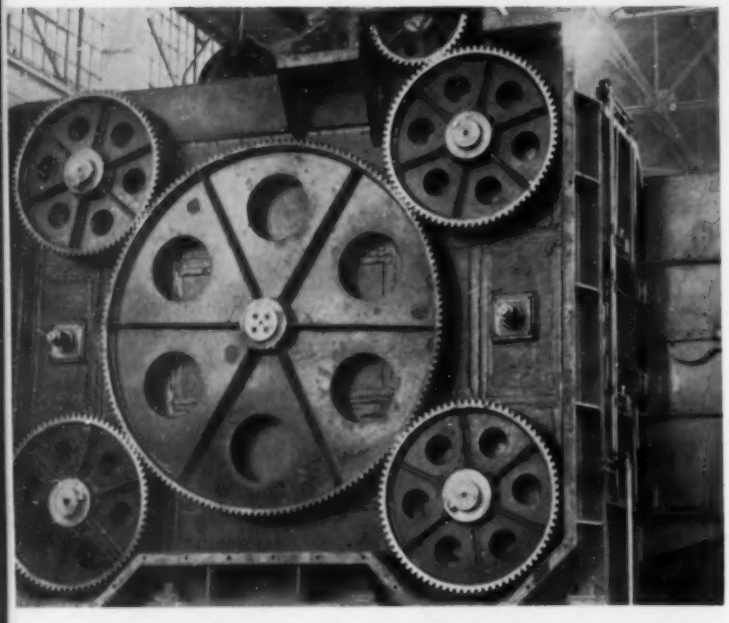


Figure 8 — Rear of main housing shows all the fabricated planetary gearing.

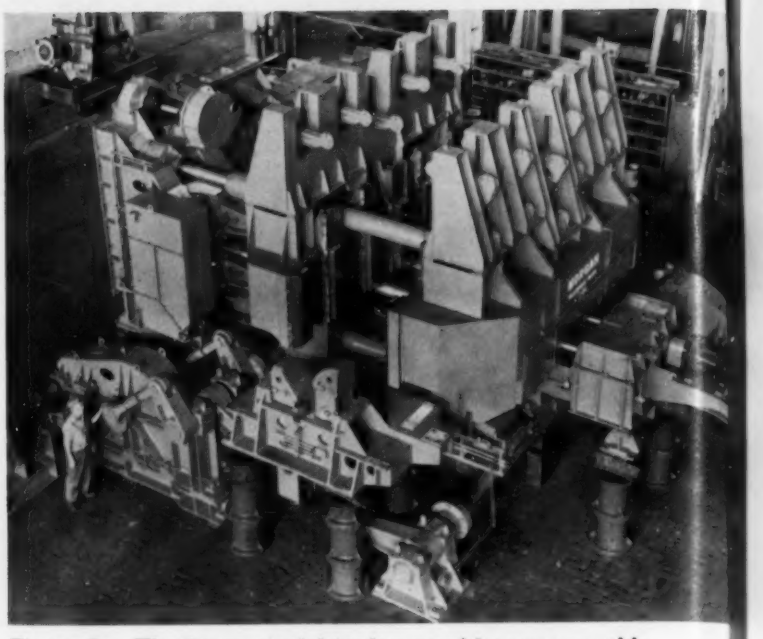


Figure 9 — The beam straightening machine was a weldment whose combined weight is approximately 1,000,000 lb.

there is a marked resemblance to a welded girder. The aforementioned situations do not occur with a welded girder, and when repairs are necessary it is a simple matter.

Some of the more recent conversions to welded construction in the mill end are table beams for roller tables, manipulator heads, and one of the largest beam straightening machines (gag press) ever built. See Figures 7, 8, and 9. The beam straightening machine is of all welded construction including the gears. This machine weighs approximately 1,000,000 lb and is being used to straighten 36-in. wide flange beams and 14-in. H-beams weighing 430 lb per ft. It exerts as high as 4,000,000 lb load when paralleling flanges.

The beam straightener was put in service in extremely cold weather without weather protection and has performed extremely well. The type of service that both the beam straightening machine and the manipulator heads must sustain give definite support that welded construction is well qualified to withstand high shock and impact loading.

It must be kept in mind that the most important single factor in a welded structure from the designer's standpoint is a well developed knowledge of good joint design. This knowledge should include the service requirements of the part, and the type of joints that can be used for the various types of service such as impact, fatigue, etc.

The other major factor from the manufacturing standpoint, is the necessity of establishing good welding procedures and welding sequences and then adhering to them.

It is the author's contention that the majority of the failures attributed to welding can be traced directly to the aforementioned reasons. Welding design should not be considered as a copy of a casting or a hit or miss proposition. Joints must be calculated and the weld sizes designated by the designer—not by the welder or fitter as was so often the case.

It is my belief that the potentialities of welding has only seen the surface scratched when it is considered that the atomic power plants are all fabricated by welding, where the slightest imperfections could be disastrous, yet this is the preferred and only method used. It gives the author the greatest confidence that a whole new era is before us in the field of welding.

DISCUSSION

PRESENTED BY

JOHN L. WOMACK, Design Engineer, Homestead Works, United States Steel Corp., Munhall, Pa.

R. D. MYERS, Assistant Superintendent, Welding, Bridge Shop, Harnischfeger Corp., Milwaukee, Wis.

C. C. BRAINARD, Structural Engineer, The Alliance Machine Co., Alliance, Ohio.

I. W. EVANS, Chief Welding Engineer, The Morgan Engineering Co., Alliance, Ohio.

J. L. Womack: Of all the welding applications discussed by Mr. Evans, I am most interested in those pertaining to girders and bridge end ties. U. S. Steel Corp.'s Homestead District Works has many cranes with welded trolley frames, bridge end trucks, bridge end ties, lifting beams, driver and follower footwalks. About 20 of these cranes have welded girders, two of which have given us considerable trouble, resulting in frequent down time and increased maintenance.

Briefly, an investigation revealed the following:

1. A crack about 30 in. long in top cover plate on two girders. This was due to trolley's jumping the rails and dropping on the cover plate, which were supported by widely-spaced light diaphragms.
2. Cracks at corner of girder notch on all corners of one crane. This resulted from poorly-designed horizontal and vertical plates of the notch.

3. An 18-in. long vertical crack alongside of vertical stiffener for connecting inside plate of end tie to girder. The exact cause of this break could not be determined. However, since the crack was about 1 in. away from weld edge, the weld itself may have caused it by creating internal concentrated stresses which under heavy services or bridge skew gave way.
4. About a third of the driver footwalk of one crane broke loose from its girder connection. This break was caused by poor design of vertical girder stiffeners, for the footwalk bracket connection.
5. On five cranes, the outside vertical plate of the cantilever portion of welded end tie supporting the outrigger girder buckled. This was caused by poor design and material too light for cantilever bracing.

The above disclosures prove that before welding critical crane equipment, the welding supervisor; the metallurgist; and the design engineer should be consulted. The combination of these three talents should give satisfactory performance of critical crane parts.

R. D. Myers: Our company went completely away from riveted girders in 1939, which I believe puts us among the first of the large fabricating shops in the country to take this major step. In the years since then we have produced over 7000 all-welded overhead cranes of various sizes. We have never produced any cranes larger than 300-ton capacity, but some of the larger ones have been quite large structures. The largest crane, physically, we have ever produced, one of 200-tons capacity for the Kaiser Aluminum Company, required two large fabricated box girders of the following dimensions: span—84 ft, web plate—$\frac{3}{8}$ in. x 102 in. deep, top plate—2 in. x 36 in. wide, bottom plate—$1\frac{1}{4}$ in. x 36 in. wide. Each girder weighed over 34 ton.

I would like to mention a few of the advantages of the all-welded crane girder over the riveted girder besides those already stated by Mr. Evans in his fine paper. For less weight it is possible to build a welded box girder of larger cross section due to the fact that you can spread the web plates from two to four inches further apart with the same size top and bottom plates. This is made possible by the elimination of the need for tie angles between the cover plates and the web plates necessary on a riveted girder. These angles are always at least 2 x 2 in. thereby requiring that the webs be set in at least $2\frac{5}{16}$ in. from each edge of the cover plates. Web plates on a welded girder may be set as close as $\frac{3}{4}$ in. from the edge of the cover plates and still have adequate space for the required welds. It is a well known fact that the wider the box section, the more lateral stiffness the girder will possess. Also, the restoration of camber, if accidently lost through an extreme overload or otherwise, is a much simpler job on a welded girder than on a riveted one in that it requires much less time, fewer tools and practically no dismantling of the crane. Another thing, since going to all-welded girders we have not had a cover plate failure. This is not surprising when you consider that in a welded girder the diaphragm plates are hard against the cover plate. This is an almost impossible feat to accomplish in a riveted girder unless you machine the tie angles with the diaphragm plates and the tie angles with the web plates. By having the diaphragm plates hard against the top plate, there can be no bending or dishing of the top plate between the webs. Since there can be no bending, there are no failures as has so often been the case with riveted girders where this bending can and does occur constantly.

We are, you might say, quite active proponents of all-welded design. We have experienced only a few minor failures since going to all-welded construction and they actually could not be called welding failures since they all occurred early in our transition period, and were all tied to lack of welding design knowledge. This welding design knowledge has greatly come of age in the last 15 years and is growing by leaps and bounds all the time. As with any new concept or idea, there are bound to be growing pains, but now we feel that the entire welding industry is out of those growing pains where steel is concerned. The gangling youth of yesteryear is now a broad shouldered rugged individualist ready to undertake any job that industry may give him, and given the opportunity will prove this on hot metal crane girders as he has in all other fields where welding application and design have been expertly applied.

C. C. Brainard: Welded construction is rapidly becoming an asset to the steel mill crane industry. In these days of increased production, it is a must to get the highest capacity, out of both new and existing cranes. The use of welding, in some cases combined with low alloy steels, provides a proven solution to this problem. Since chord angles are not necessary on welded girders, it is possible to obtain greater lateral strength and stiffness. For this reason, welded girders have greater resistance to the lateral and torsional loads which eliminates the need for outrigger girders, except in the extreme cases. The stiffness of end ties, soaking pit guide frames, charger collector masts and similar items are materially increased by the use of welding and this is usually accompanied by a savings in material. In addition, weight reductions are obtained by use of weldments for end trucks, motor bases, gear boxes and trolley frames. These savings, when combined with the decrease in mechanical and electrical components allow a higher useful capacity for a given dead weight. This results in lighter supporting structures, and also higher capacity cranes on existing runways.

One of the early mistakes in the design of welded construction was the over-use of weld metal. As Mr. Evans pointed out, every joint must be designed for economical fabrication. Too much welding not only wastes weld metal and labor, but also can produce distortion in the weldment. This distortion is accompanied by stresses which cannot be completely removed by stress-relieving. If such a weldment requires machine work, inaccuracies often arise when the planes of these stresses are cut. The advancement of welding procedure and the use of proper design techniques are minimizing these problems and are eliminating the source of many objections to welded construction.

Mr. Evans' comments on the automatic girder welding equipment are interesting as we obtain essentially the same results with two independently operated, self-propelled machines which actually run on, and are

guided by, the girder cover plates. These machines are of the submerged arc type and can also be used for welding drums, splicing plates and various other jobs in our shop. We have found that in addition to sounder, more uniform welds, the use of the machines allows us to control the straightness and camber with much more precision.

One of the newest developments in the field is the use of carbon dioxide with the gas shielded systems such as sigma, aircomatic or filler arc. Carbon dioxide provides an inexpensive gaseous shield for these machines and according to early reports produces sound welds with very good penetration when used with mild steel. I would like to know if Mr. Evans has made any tests on this type of welding procedure, and if so, what results were obtained.

I. W. Evans: I should like to thank Mr. Womack, Mr. Myers and Mr. Brainard for their interesting and informative discussions. Mr. Womack helped point out a major fallacy in that welding design cannot be a hit or miss proposition. You must know the service requirements and design for them.

Mr. Myers mentioned that among the many advantages of welded design over riveted is that of weight and cost reduction. The weight reduction is particularly important where building loads are critical but the major advantages are definitely in the additional strength obtained and the reduced costs of fabrication.

Mr. Brainard, one of our friendly competitors who is also a neighbor, mentioned the new welding process where carbon dioxide is used as the shielding medium. This process offers many advantages since the complete welding process is visible to the operator and the carbon dioxide is relatively inexpensive in comparison to other shielding gases heretofore considered adaptable to welding of mild steel. Carbon dioxide welding is not new in concept, but previous experiments indicated that special steels were required to obtain porosity-free welds with this process. I understand that the problem has now been overcome. This process could possibly make the submerged arc process obsolete, but I personally do not feel that it has been tried and tested sufficiently to warrant using it in products that are subjected to extreme service conditions, such as those built by our company.

HEATING UP OPEN FURNACES WITH NATURAL GAS*

▲ OUR program of lighting-up furnaces at The Colorado Fuel and Iron Corporation, after rebuilds, has now reached the stage of development where savings of half a million dollars per year in more production, better roof life, and lower fuel costs appear likely for our 16-furnace shop at Pueblo. The first three full years, while we were "growing into" the present process, saved over $220,000 in light-up time alone, calculated on furnace time being worth $150 per hour.

The present practice is to install a burner in each checker chamber bulkhead. A three-inch gas line has been installed in the cellar the length of the shop. The line carries 970-Btu gas with a line pressure of 35 psi. The fuel input through the four checker burners ranges from 10,000 cu ft at the start to a maximum of 90,000 cu ft when the main burners take over the light-up. These burners are of a design developed to aspirate sufficient air for combustion at maximum fuel flow. The burner consists of an 8-in. shell, 24 in. long.

A one-inch pipe bent in the form of a "doughnut" is spotwelded to the outer end of the burner. Thirty-six $\frac{3}{16}$-in. holes are drilled in the "doughnut" at such an angle that the gas meets six inches from the end of the burner. Each burner is individually controlled. A four-point temperature recorder is set up in the cellar between the checker chambers. Three thermocouples located in the crown of the roof at 1, 3, and 5 doors guide the light-up man as he regulates the fuel input rate. These thermocouples are placed in three roof bricks which have been drilled to ½-in. of the inner roof face.

Dampers and mushrooms are closed until the center thermocouple in the roof reaches 900 F. The dampers and mushrooms are then connected and the first helper begins reversing the furnace at five minute intervals. This is continued until the roof temperature reaches 1200 F. The gas is then put through the main burner and, about one hour later, the oil is put on. The checker burners are shut off and removed at about 1800 F and, at this time, checkers and stack are at maximum temperature. Furnace reversals continue on the five minute cycle until the roof temperature reaches 2400 F.

Unless the furnace hearth has been resurfaced, the furnace is completely charged before the light-up begins.

With the use of checker burners, ground rebuild have been reduced to an average of 27 hours; floor rebuilds to 25 hours and 50 minutes and quick roofs to 22 hours and 30 minutes. We have established a desired maximum light-up time of 22 hours for shotgun or quick roof and 24 hours for floor and ground rebuilds.

The hearth burner light-up method gave us a uniform temperature rise in the hearth, but we experienced damage to brick work in the fantail arches when the dampers were raised after hearth temperature had reached 1200 F. In placing a thermocouple in the fantail arch, we found a temperature rise of 900 F in 10 minutes. This extreme temperature caused considerable damage by spalling of fantail arch brick, and repair was often necessary before the end of the furnace campaign.

The saving in actual light-up time is a small portion of the total savings. With the use of checker burners the furnaces are producing steel at their maximum rate after the second heat, which makes it unnecessary to take five days or a week to get checkers and sewers up to maximum operating temperature.

Light-up temperature rates are as follows: 125 F per hour until roof reaches 600 F, then 150 F to 800 F, 200 F to 1200 F. At this point full expansion has been reached, and the rate is increased to 400 F up to 2400 F when the light-up is considered complete.

*Abstracted from paper by George E. Grosvenor, Open Hearth Supt., The Colorado Fuel and Iron Corp., Pueblo, Colorado, at Chicago Regional Meeting of AISI, Nov. 2, 1955.

Paper compiles present available empirical and theoretical information needed to select drive equipment for hot strip mills . . . . form for presenting data promises easier interpretation and application.

Power Requirements and Selection of electric equipment for hot strip mills

By R. E. MARRS
Steel Mill Engineer
Systems Application Engineering Section
General Electric Co.
Schenectady, N. Y.

▲ MODERN hot strip mills require large investments in both mechanical and electrical equipment. It is folly to over-invest in equipment which may not be necessary. It is a greater folly to improperly select one single component which may curtail the production of an entire plant. The incorrect speed or horsepower rating of just one mill stand motor may cause a bottleneck through which profits cannot pass.

There are two types of high production hot strip mills. One of these is called a continuous mill. It usually consists of four or five roughing mill stands followed by a train of six finishing stands. The other semi-continuous type may use only one reversing rougher ahead of a similar train of finishing stands.

The world's tonnage record is held by a continuous mill. However, some of the more recent semi-continuous mills have obtained outstanding production records. The use of long slabs has contributed to the increased rolling rate of both types of mills.

A reversing rougher does provide for working the metal in two directions whenever that may be considered advantageous. It allows for considerable flexibility in the selection of motor horsepower and the number of rolling passes. The reversing rougher needs less mill area, especially when long slabs are to be rolled. A continuous roughing train driven by constant speed a-c motors requires that the stands be spaced far enough apart so that a slab is never in more than one mill at a time.

There are at least two continuous mills in operation which have adjustable speed d-c motors on the roughing stands. These motors permit the stands to be located close to each other so that a slab may be in all stands simultaneously. The arrangement does save mill area, but the d-c drives are more costly. Most studies which have been made on such arrangements point with favor toward the use of either a-c driven continuous roughers or one d-c driven reversing rougher.

The actual power requirements for rolling steel with any of these arrangements may not differ much. Likewise the problems in selecting electric equipment for them are quite similar. This paper will for an example use a typical continuous mill with four a-c roughing stands and six d-c finishing stands.

DRAFTING PRACTICE

In determining the power requirements for any form of rolling mill, we must first define the work to be done. It is customary to first review rolling practice on existing mills. This may or may not be a reliable guide. Drafting practice often becomes established from habits which are not too well founded. For example, suppose we select a certain schedule for rolling light gage material based on some existing mill practice. The center of load distribution will probably be toward the delivery end of the finishing train. Then if we select a typical schedule for heavy gage material, the rolling rate in tons per hour for a specified total load will be greater. However, if again we follow some existing drafting practice, the center of load distribution will probably be shifted more to the entry end of the finishing train.

It is therefore important to study drafting practice to determine the best use of rolling power. Figure 1 shows a chart of some typical drafting practice. This represents a practice which has apparently proven acceptable from the standpoint of temperature control, physical shape, metallurgical aspects, etc., and perhaps a compromise on stand power distribution.

It will be noted that there is a tendency to deliver about 0.75 in. thick material from the No. 4 rougher onto the holding table for entry into the finishing train. The line from an 8-in. slab to a ¾-in. slab is drawn for the basis of an example calculation. Such reductions would not normally be taken on four roughing passes. It is used later only to illustrate the magnitude of power involved and what can be done electrically.

Figure 2 is a chart of the same drafting practice expressed in the form of per cent reduction per pass. Some operators prefer to work with rolling reductions expressed in this manner.

Others will prefer the drafting to be expressed in the form of elongations shown in Figure 3. This form is particularly advantageous when it becomes necessary to determine the relative speeds between mill stands. The

maximum elongation which can be handled by the finishing train depends on the ratio of the maximum speed of the last stand to the minimum speed of the finishing mill scale breaker. For rolling 0.75 in. to 0.05 in. this ratio or elongation must be 15. This ratio is necessary in order to have the same volume of steel pass through each stand in a given unit of time.

Likewise, such a chart is useful in determining the relative speeds of the roughing mills for various slab thicknesses. For example, if we assume an 8-in. slab reduced to 0.75 in. then the overall elongation must be 10.7. The speeds selected to obtain these elongations will influence the power requirements for the roughing mills. The speed will be influenced by the time required for cooling and scale formation on the holding table and of course by the rolling rate of the finishing train. There are many such aspects that enter into the choice of roughing mill speeds, and as a result, the operating speeds of existing installations may vary over a considerable range. The following tabulation is believed to be reasonably typical of both American and European practice:

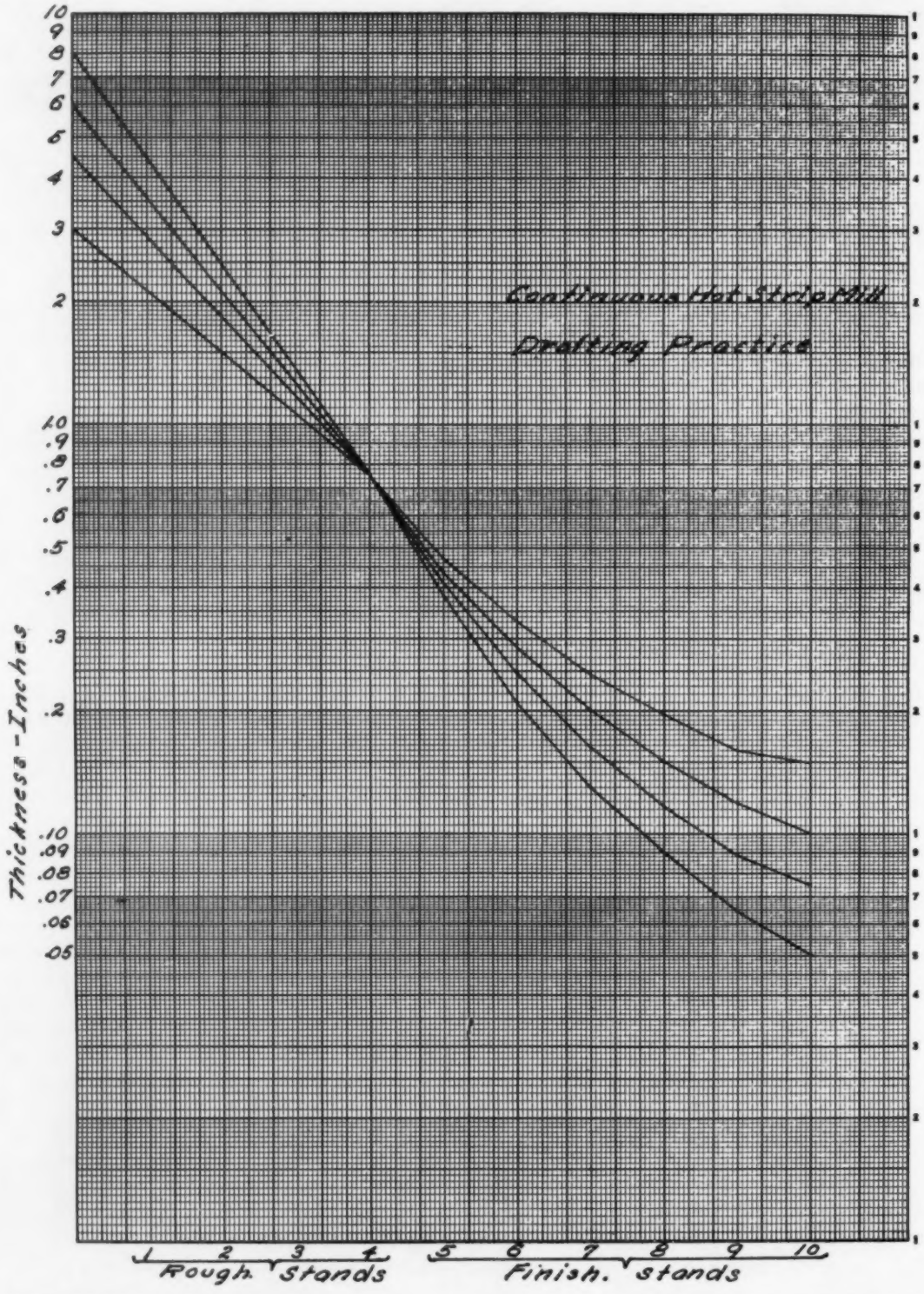


Figure 1 — Typical drafting practice on continuous hot strip mills is given by curves. Note entry thickness into finishing stands is about ¾ in. regardless of original slab thickness.

Stand No.	Speed, fpm
Rougher 1	190
Rougher 2	225
Rougher 3	320
Rougher 4	450

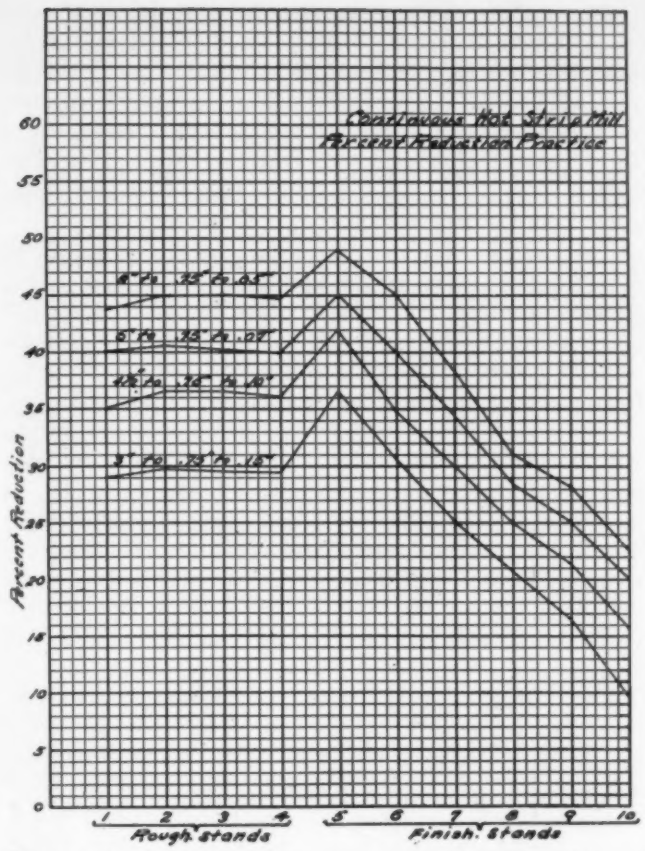
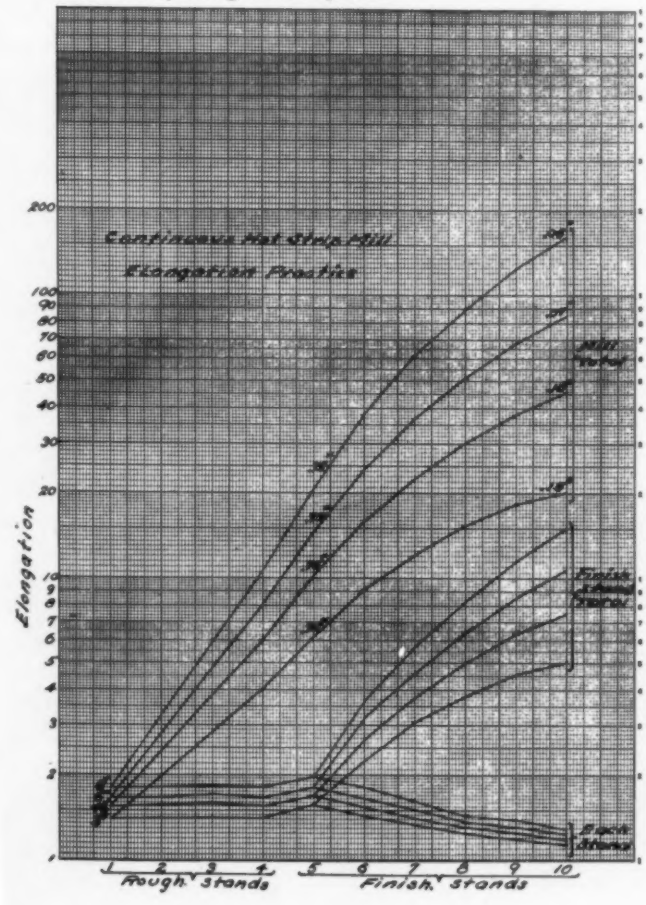


Figure 2 — Curves give same drafting practice as Figure 1 except expressed in terms of per cent reduction.

Figure 3 — Curves give same drafting practice as Figure 1 in terms of elongation which is more convenient when computing stand speeds.



A fifth roughing stand would distribute this speed range a little differently and perhaps require the average speeds to be a little higher. Similarly, a spreading stand might require the delivery speed of the roughing train to be a little higher in order to obtain the desired production.

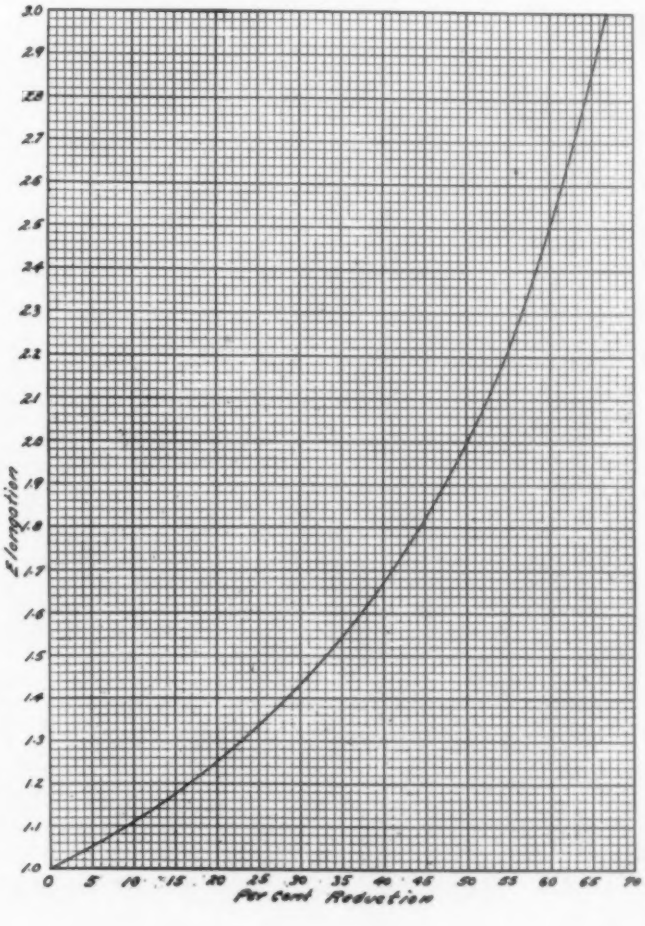
Figure 4 shows a curve which is convenient to use in converting per cent reduction to elongation, or vice versa. It covers the drafting range usually required of a single mill stand.

These charts are quite elementary in principle, but extremely useful in detremining the best choice of rolling schedules. They are shown with sufficient cross lining to be read accurately.

MOTOR HORSEPOWER SELECTION

In the determination of power required to roll steel, there is perhaps a tendency for the mill designer to consider roll forces, lever arm, speed, and other mechanical aspects of the mill. The electrical engineer finds it more convenient to use power data derived from actual tests on similar mills. This power data is usually put in the form of "power curves" where "hp-hr per ton" of steel is plotted against the per cent reduction or actual elongation. The power quantities are net values of energy delivered to the mill rolls. Mill friction losses are neglected because they are relatively small, and appropriate consideration of them can be made after the actual rolling loads are known. Figure 5 shows a typical power curve for rolling mild steel from various slab

Figure 4 — Chart shows conversion between per cent reduction and elongation.



thicknesses. The hp-hr per net ton is a summation of the hp-hr per net ton of all passes down to and including any particular thickness. The net tons per hour is obtained from the simplified expression

$$\text{Net tons per hr} = \frac{\text{width} \times \text{thickness} \times \text{fpm}}{10}$$

This is based on a hot steel weight of 0.279 lb per cu in.

In using such power curves, it is desirable to select one based on comparable slab size, temperature, and rolling speeds of a similar mill. It has been determined that the power required to roll steel does not vary with small changes in operating speed. Power requirements are, however, greatly affected by temperature, and the curve shown here is applicable only when rolling temperatures are reasonably close to those indicated. This is essentially the same power curve data which was presented to the Association of Iron and Steel Engineers about fifteen years ago by Mr. T. R. Rhea and Mr. W. M. Ballinger. "Power Consumption of Hot Strip Mills," 1941 Proceedings AISE, p 142. It has withstood the test of time remarkably well, and it should be given a new look. The curves have been drawn with more fine cross lines to promote accuracy in reading.

Table I gives a typical power calculation based on this power curve. An assumed slab, 8 in. thick, 48 in. wide and 20 ft long is rolled to 0.05-in. thickness at 2400 fpm. Individual stand reductions are made in accordance with the previous typical drafting practice schedule. The total hp-hr per ton are read off the curve for each thickness and the individual stand hp-hr per ton is the total after each stand less the corresponding total after the previous stand. This individual stand hp-hr, multiplied by the net tons per hour gives the stand net rolling hp. The actual root-mean-square hp is the net rolling hp multiplied by the square root of the ratio of the actual rolling rate to the desired rolling rate. The motor must be able to handle the peak net rolling load as well as the root-mean-square or heating load.

The total seconds per pass are included as a matter of interest. If a roughing mill pass is five seconds or more, there is no practical advantage in the use of a wound rotor motor with flywheel. Synchronous motors are usually preferred because they have the advantage of lower cost, higher efficiency and better power factor. These motors can be designed for various maximum torque ratings. Values of 250, 300 and 350 per cent are reasonable, economical and can be provided in rugged mill type motors. It is desirable to provide a margin of about 100 per cent rated torque in these motors over and above the actual peak torque requirements. Such a margin will allow for some variations in steel temperature, actual rolling reductions and variations in supply voltage.

For this example, the rolling rate has been chosen to be 500 tons per hour, or about 87 per cent of the finishing mill maximum rate when rolling 0.05-in. material at 2400 fpm. This actual rolling rate determines the root-mean-square horsepower load and the necessary motor rating. Some present day mills may roll strip-after-strip with such close spacing that strip is never out of more than one finishing mill at a time. When this occurs the root-mean-square motor load practically equals the

Figure 5 — Typical power curves for rolling mild steel from varying slab thicknesses are given by chart.

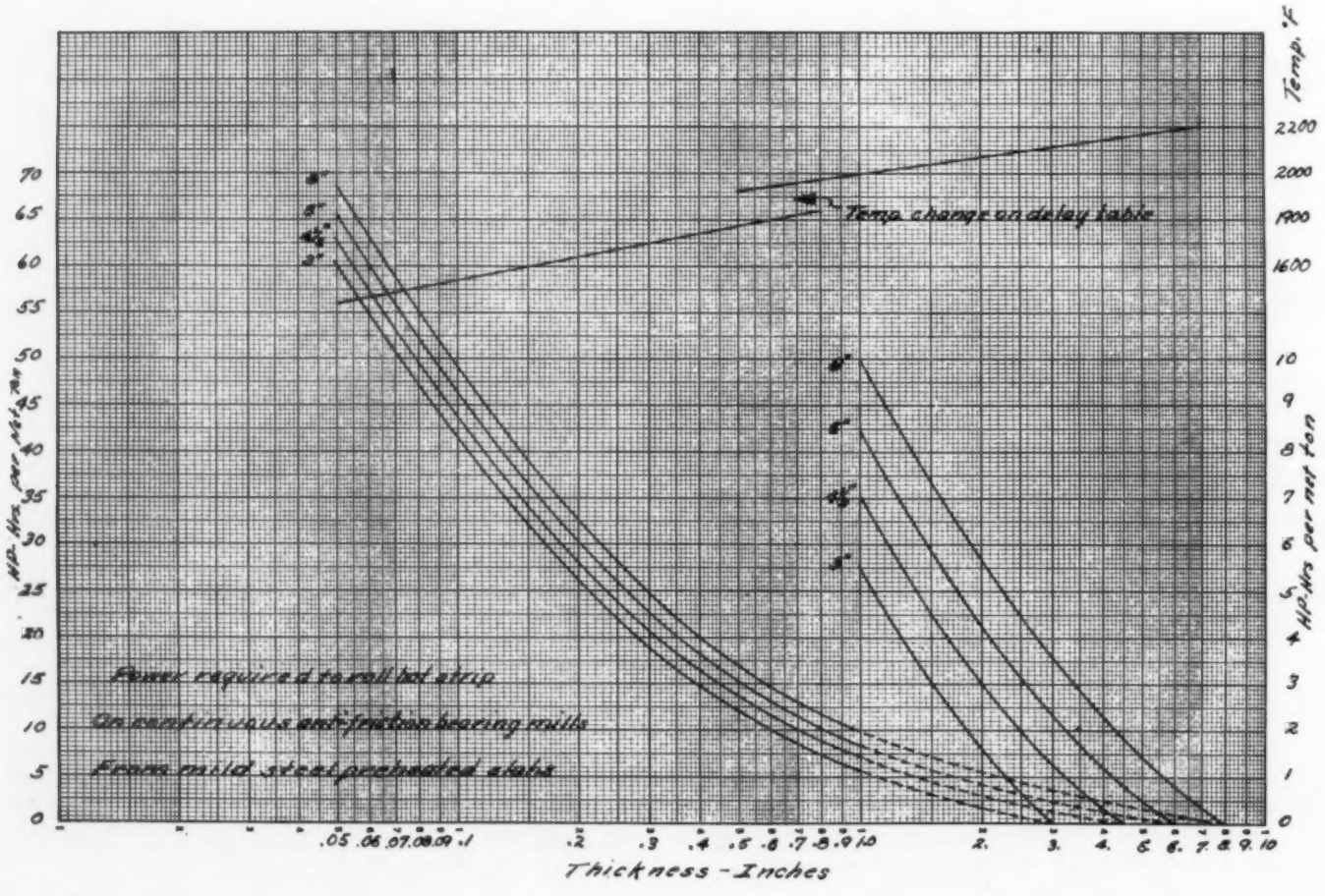


TABLE I

Rolling 0.05-in. Strip from Slab 8 x 48 x 240 in. (12.8 Tons)

Stand	Thickness	Width	Per cent reduction	Elongation	Delivered fpm	Sec per pass	Net tons per hr	Total hp-hr per ton	Hp-hr per ton per pass	Net rolling hp	Root-mean-square hp	Motor rating, hp
	8	48	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
SB1	8	48	0	0	.....	.....	.....	.....	.....	.....	.....	.....
R1	4.5	48	43.8	1.78	190	11.2	4100	1.8	1.8	7280	2540	2500
R2	2.5	48	44.5	1.8	225	17.1	2700	4.5	2.7	7300	3150	3500
R3	1.35	48	45.6	1.85	320	20.4	2080	8.0	3.5	7300	3580	3500
R4	0.75	48	44.8	1.80	450	28.4	1620	12.4	4.4	7100	3940	4000
SB2	0.75	48	0	0	160	.....	.....	.....	.....	.....	.....	.....
F5	0.38	48	49.5	1.97	314	80	576	21	8.6	4950	4600	5000
F6	0.21	48	45.0	1.82	574	80	576	31.7	10.7	6150	5730	6000
F7	0.13	48	38.1	1.615	925	80	576	42.5	10.8	6220	5800	6000
F8	0.09	48	31.0	1.445	1340	80	576	51.8	9.3	5350	4980	5000
F9	0.0645	48	28.3	1.395	1865	80	576	61.2	9.4	5420	5050	5000
F10	0.05	48	22.5	1.29	2400	80	576	68.5	7.3	4200	3920	4000

$$\text{Net tons per hr} = \frac{\text{width} \times \text{thickness} \times \text{fpm}}{10}$$

Total hp-hr per ton = from power curve.

Pass hp-hr per ton = total at pass — total preceding pass.

Net rolling hp = hp-hr per ton × tons per hr

$$\text{Rms hp} = \sqrt{\frac{\text{actual rolling tons per hr}}{\text{net tons per hr}}} \times \text{net rolling hp}$$

Actual rolling rate assumed to be 500 tons per hour for 0.05 in. steel.

peak load and the motor ratings must be adjusted accordingly.

The ratio of peak load to the root-mean-square load is usually greatest in the roughing mills. When this ratio is, for example, 2 to 1, the motor would be selected with 300 per cent peak capacity to provide the margin suggested above. The roughing mill motors shown in Table I should have something over 300 per cent peak capacity. It will be shown later, however, that these ratings will have to be increased when finishing heavier gages at greater ton per hour rates.

It is desirable and common practice to make several of the motors duplicate in horsepower rating and duplicate in speed rating where the necessary gear ratios prove economical.

The finishing mill motors may be required to carry the maximum peak load at their top speed rating. It is recommended therefore that the peak loads do not exceed 150 per cent of the rated root-mean-square load. The ratings shown in Table I are well within this requirement.

If a broadside or spreading stand is used, the drafting necessary is determined by the elongation or ratio of desired width of slab to the original slab width. A slab squeezer usually follows a spreading stand. This unit squares up the slab and reduces the width about 3 in. The spreading operation must therefore make allowance for the width lost in a slab squeezer.

There is some inherent spreading of the slab in all roughers. This usually ranges from ½ in. in No. 1 rougher to ⅛ in. in No. 4 rougher. Separately driven vertical edging rolls are frequently used to correct the result of this spreading. A single edging draft is usually not over ½ in., mainly because of the high ratio of slab width to slab thickness. Power for those drives, in the order of 150 to 200 hp, is usually supplied by 230-volt adjustable speed mill type auxiliary motors.

The reduction taken on a scalebreaker ahead of the roughing train may vary from zero to 15 per cent. The prime purpose of the scalebreaker is to remove scale and thereby prevent the effects of its being rolled into the slab by the roughing mills. Attempts to even up slab thickness with scalebreakers by excessive drafts may result in some rolling-in of scale. Therefore, power requirements on the roughing mill scalebreaker are relatively small.

Although any elongation resulting from the scalebreakers has been neglected in the above example, typical motor ratings of 800 and 500 hp for the No. 1 and No. 2 scalebreakers respectively have been included.

SIMPLIFIED "POWER CURVE"

The previous example represents the manner in which motor horsepower ratings have usually been selected with the aid of power data curves. Figure 6 shows the previous power data curve in another form. With this form, we locate the point where a desired value of entry thickness intersects a desired value of delivery thickness and read the hp-hr per ton directly. For example, going from 1.0-in. thickness to 0.4-in. thickness requires 10 hp-hr per ton. If, as in the previous example, the tons per hr $\frac{(\text{thickness} \times \text{width} \times \text{fpm})}{10}$ is 576, the net motor load is 5760 hp. If we desire to know the total power required to reduce 0.75-in. slab to say 0.05-in. thickness, the chart reads about 56 hp-hr per ton. This multiplied by the 576 tons per hour of the previous example, totals 32,300 hp for the finishing train. This would normally be distributed over six separate mill stand motors.

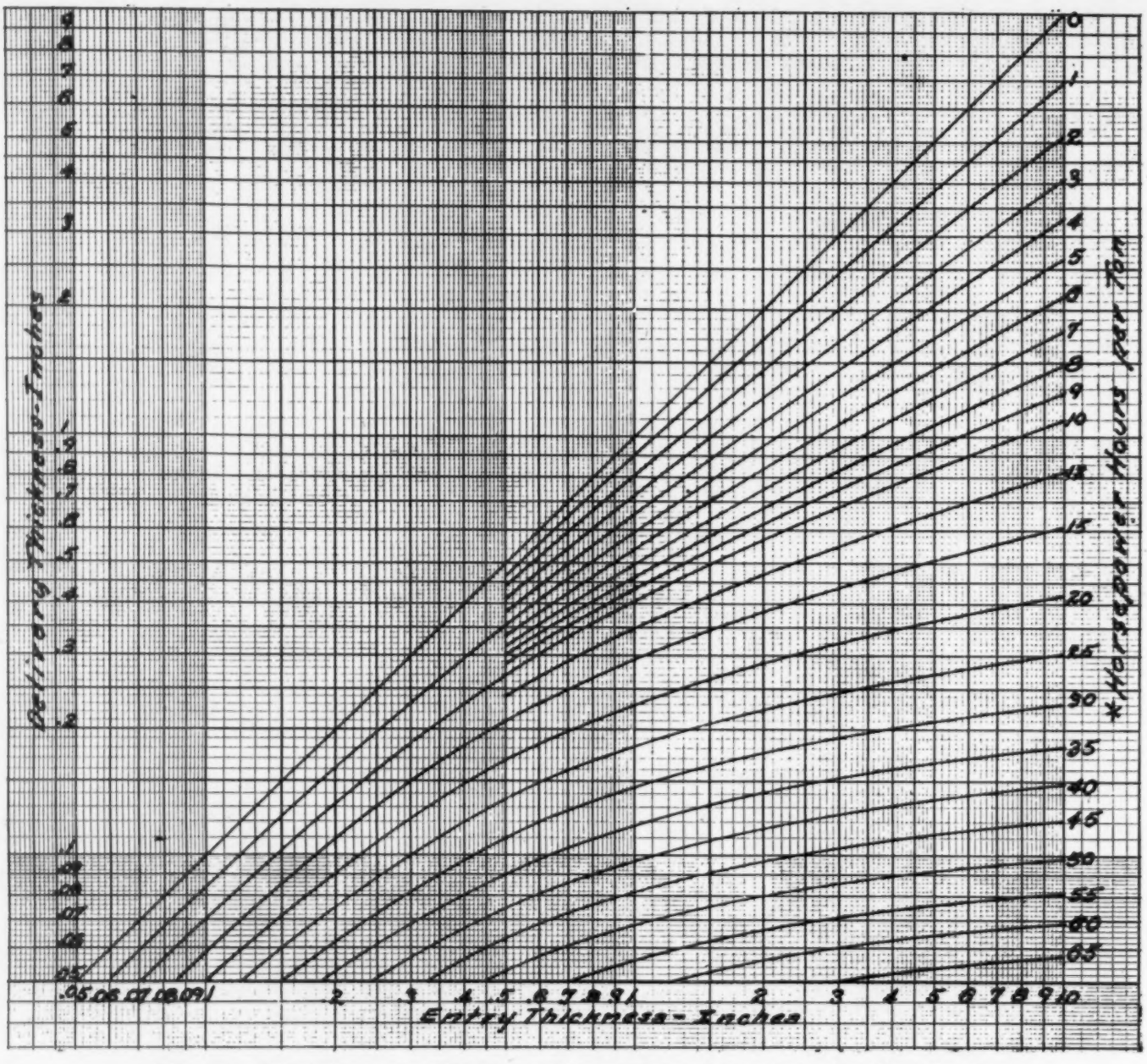


Figure 6 — Chart gives a simplified form of the power required to hot roll mild steel strip.

This curve sheet of Figure 6 is based on starting with an initial slab thickness of 8 in. For any other slab thickness we should, for greatest accuracy, have a separate curve sheet. However, it will be found that for other slab thickness the hp-hr per ton can be adjusted in the ratio of about 1 per cent decrease for each corresponding ½ in. decrease in slab thickness. Most of the error resulting from this assumption will occur in the roughing mill end and the calculated value will tend to be high. The accuracy of this method should, however, be as good as the accuracy of the data on which the original power curve was calculated.

This is believed to be a new form of power curve, not previously published. It should provide a means for anyone to determine motor load for a specified rolling schedule of mild steel, or for anyone to adjust rolling loads to a specified motor capacity. Likewise, it suggests a convenient method of plotting power data for other materials. The necessary data for plotting such a curve can be obtained from individual stand power readings taken from time to time. It is not necessary to have an elaborate set of instruments to obtain valuable data. Many mills are now equipped with X-ray gages. From known dimensions and speed of delivered strip, we can obtain the tons per hour. From known mill speeds, we can determine the elongation or actual thickness of strip at each stand. Motor load can be obtained with ordinary measuring instruments at motor terminals.

Such a form of power curve is useful in the determination of the overall mill power, as well as that for the individual stands. In the example above, it was shown that the finishing mill requires a total of 31,000 stand motor hp for 0.75 in. to 0.05 in. mild steel at 2400 fpm and 500 tons per hour. If now, most of the rolling schedule were to be 0.75 in. to 0.15 in. (26.6 hp-hr per ton), then this same finishing train hp could theoretically deliver about 1165 tons per hour at 1620 fpm. However, if we follow the drafting practice previously indicated for this gage of strip, the first three finishing

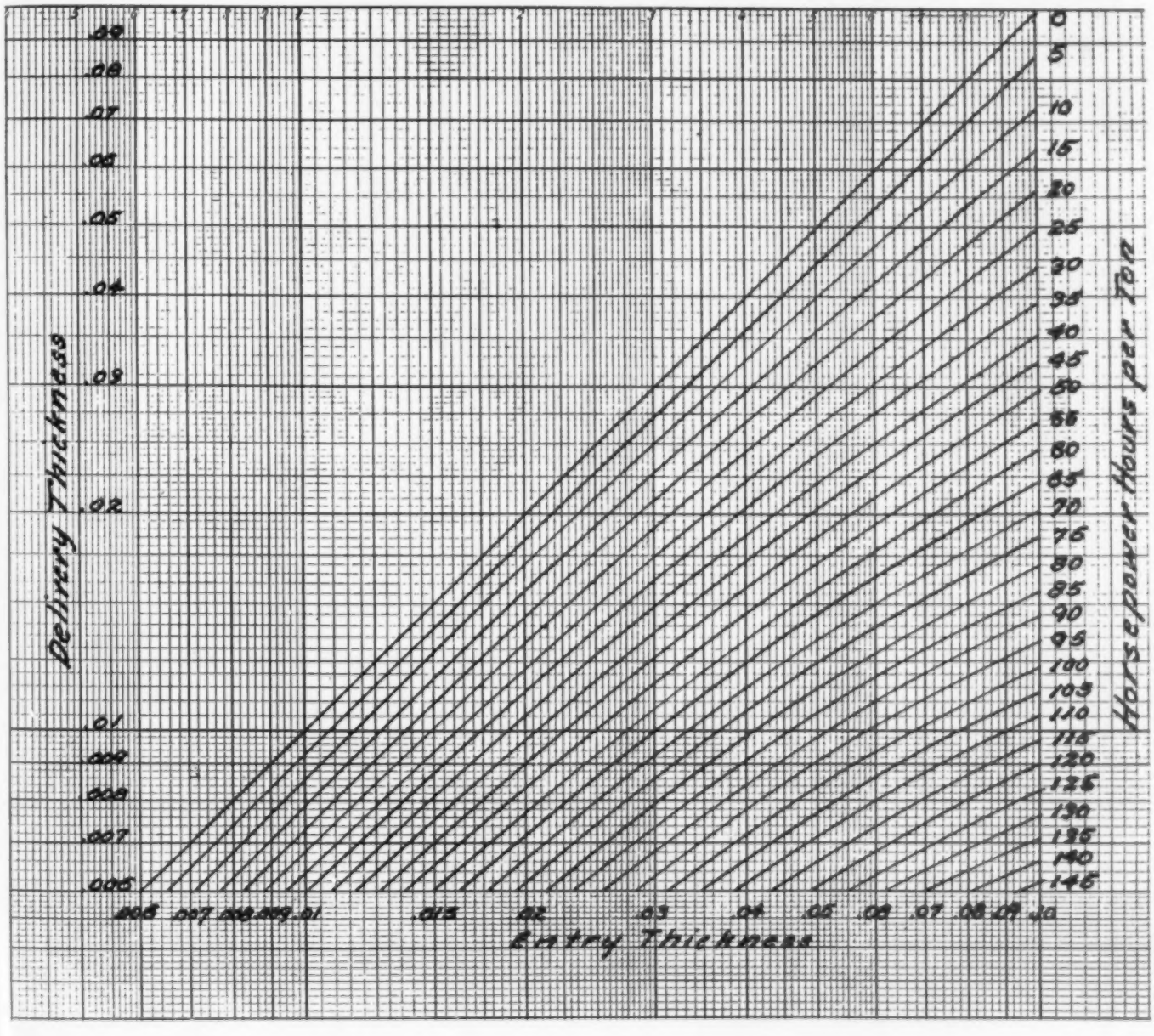
TABLE II

Rolling 0.15-in. Strip from Slab 8 x 48 x 240 in. (12.8 Tons)

Stand	Thick-ness	Width	Per cent reduction	Elonga-tion	Deliv-ered fpm	Sec per pass	Net tons per hr	Total per ton hp-hr	Hp-hr per ton per pass	Net rolling hp	Root-mean-square hp	Motor rating, hp
SB1	8	48	0	0	.....	.....	.....	.....	.....	.....	.....	800
R1	4.5	48	43.8	1.78	190	11.2	4100	1.8	1.8	7280	3210	3500
R2	2.5	48	44.5	1.80	225	17.1	2700	4.5	2.7	7300	3970	4000
R3	1.35	48	45.6	1.85	320	20.4	2080	8.0	3.5	7300	4600	5000
R4	0.75	48	44.8	1.80	450	28.4	1620	12.4	4.4	7100	5000	5000
SB2	0.75	48	0	0	.....	.....	.....	.....	.....	.....	.....	500
F5	0.475	48	36.6	1.58	505	40	1150	17.6	5.2	5980	5000	5000
F6	0.330	48	30.5	1.44	730	40	1150	23.1	5.5	6330	5300	6000
F7	0.248	48	25	1.33	970	40	1150	28.4	5.3	6100	5100	6000
F8	0.197	48	20.6	1.26	1220	40	1150	32.8	4.4	5070	4220	5000
F9	0.165	48	16.3	1.19	1450	40	1150	37	4.2	4830	4020	5000
F10	0.15	48	9.3	1.1	1600	40	1150	39	2.0	2300	1920	4000

$$\text{Rms hp} = \sqrt{\frac{800 \text{ tons per hr}}{\text{net tons per hr}}} \times \text{net rolling hp}$$

Figure 7 — Chart gives power required to cold roll mild steel strip. Formulae used are: tons per hr = thickness x width x fpm x $\frac{1}{9.82}$, and tension hp = 3 x tons per hour x $\frac{\text{(back tension-front tension)}}{10{,}000}$ psi.



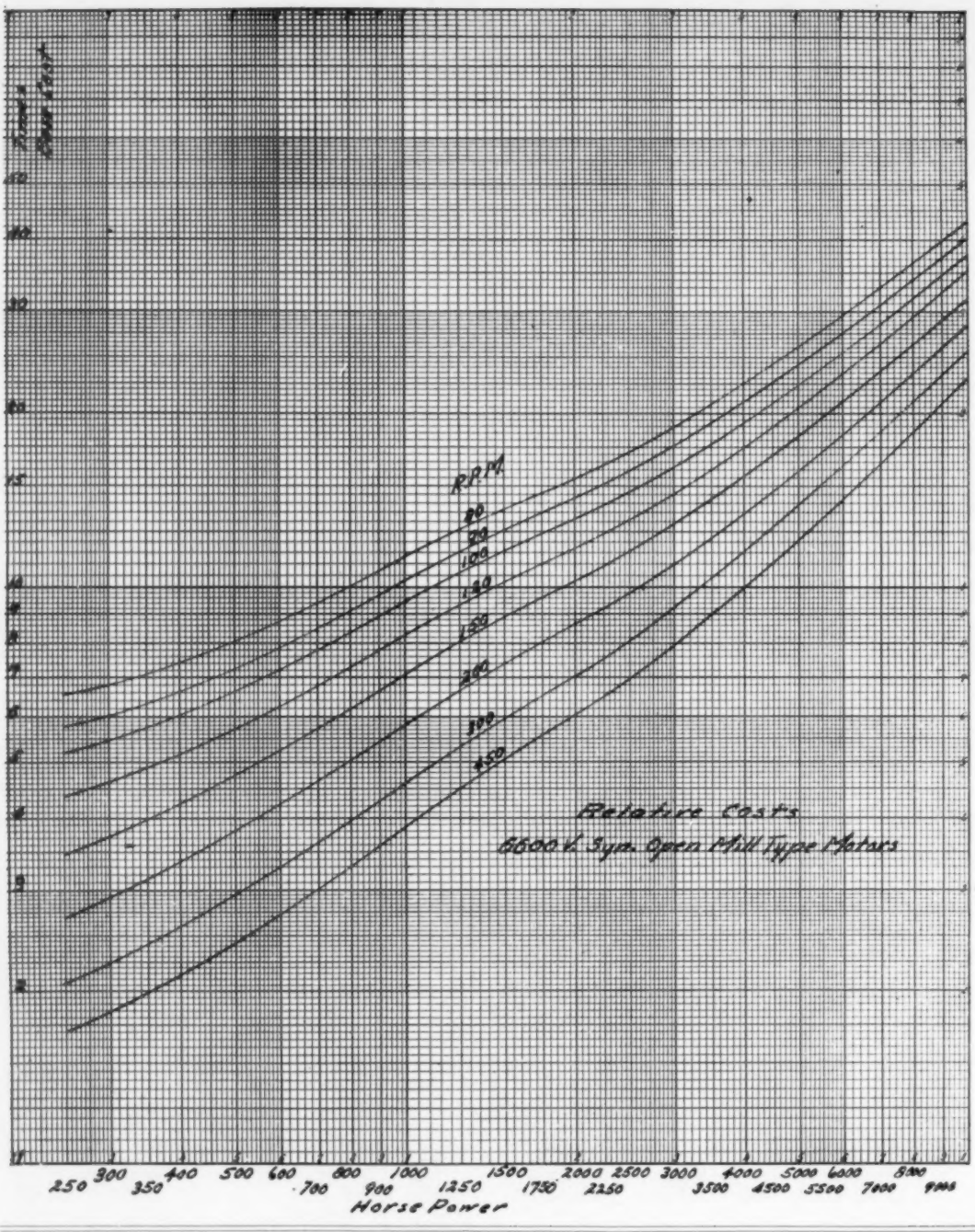


Figure 8 — Relative cost of synchronous mill motors.

stands would be overloaded. We must either shift some of the drafting toward the finishing end or reduce the tons per hour. A 5000-hp motor on the first finishing stand would be fully loaded reducing 0.75 to 0.475 (which require 5.2 hp-hr per ton) at 960 tons per hour.

There are some fundamental relationships between horsepower, tons per hour, and speed which are most conveniently expressed in the following formulae:

a. $$\text{Net tons per hour} = \frac{\text{width} \times \text{thickness} \times \text{fpm}}{10}$$

b. $$\text{Net rolling hp} = \text{hp-hr per ton} \times \text{tons per hr}$$

c. $$\text{Rms hp} = \sqrt{\frac{\text{actual tons per hr}}{\text{rolling tons per hr}}} \times \text{net rolling hp}$$

These may be arranged as follows:

d. $$\text{Fpm} = \frac{\text{rolling tons per hr}}{\text{width} \times \text{thickness}} \times 10$$

e. $$\text{Rms hp} = \sqrt{\text{actual tons per hr} \times \text{rolling tons per hr} \times \text{hp-hr per ton}}$$

f. $$\text{Tons per hr} = \frac{(\text{rms hp})^2}{(\text{hp-hr per ton})^2 \times \text{actual tons per hr}}$$

The latter form gives the net rolling rate for a given motor when carrying a specified actual rolling rate. Assume that the actual rolling rate for one hour is 800 tons. This in all probability will be limited by the slab reheating furnaces, or perhaps the roughing mills.

Then the critical first finishing stand 5000-hp motor can roll 0.75 to 0.475 in. material at:

$$\text{Tons per hr} = \frac{5000^2}{5.2^2 \times 800} = 1150 \text{ tons per hr}$$

It is interesting to note that rms hp is constant so

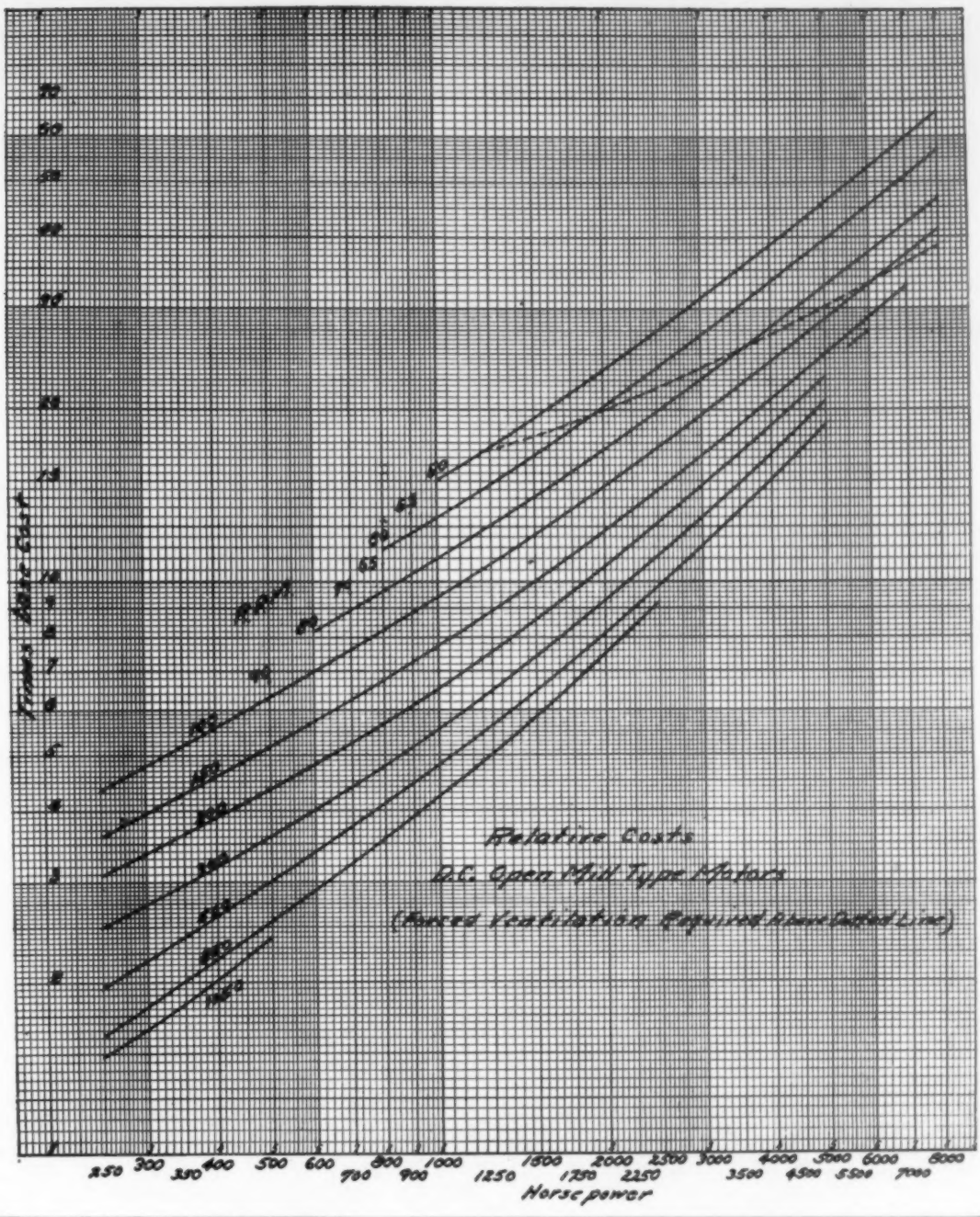


Figure 9 — Relative cost of d-c mill motors.

long as the product of actual rolling rate and net rolling rate is constant. The tons per hour delivered by the finishing mill could be increased by rolling at a lower speed provided the actual tons per hour delivered by the roughing mill could be increased.

The tons per hour of the roughing mill could be increased by rolling to 1-in. slabs instead of 0.75-in., and the speed of finishing mill might be lowered to handle this rate. Again, the drafting practice dictates what horsepower and speeds are required.

Table II is a tabulation based on rolling 0.15 in. material, 48 in. wide from 8-in. slabs at the rate of 800 tons per hour. It will be noted that all of the roughing mill motor sizes had to be increased. However, if No. 1 rougher motor were made 4000 hp to duplicate No. 2 motor, all rougher motors need not have over 300 per cent peak torque capacity.

The finishing mill motors have the ratings required for rolling 0.05 in. material. It should be noted, however, that the rolling load has been shifted toward the first finishing stand. The distribution of motor load would be more uniform if some of the reduction could be shifted toward the finishing end. This ought to be an acceptable change in drafting practice on heavy gage material.

It is even more important to check the loading on the first finishing stands when rolling the heavier finish gages from 1-in. material delivered by the roughing mills.

In Figure 7, it is interesting to observe the same form of power curve for cold rolling of mild steel strip. Good use was made of this curve in the selection of motor sizes on a very recent high speed tandem cold mill.

It will be noted that to cold roll from 0.1 in. hot band to 0.085 in. thickness requires five hp-hr per ton. This is the same amount of power indicated in the previous chart to hot roll the same thickness. The two curves seem to indicate that mill people have been right in separating hot and cold rolling operations at this level from the standpoint of power requirements. However,

since the practical maximum speed for a hot strip mill seems to be about 2400 fpm, the only way to get more tons per hour of a given width is to encourage the cold mill operators to accept thicker strip.

MOTOR SPEED SELECTION

After we have determined the horsepower requirements of a mill, we must next select the driving motor speeds and gear ratios.

In selecting a gear ratio, the cost of motor hp at various available speeds should be considered. Quite often a small change in gear ratio will result in considerable saving in motor cost. Conversely, the selection of lower speed motors for direct-connection may offer advantages that will offset the increased motor cost. There is one hot strip mill in operation where all of the four finishing stand motors are direct connected. However, this does necessitate that all motors have a different speed rating, and the advantages of motor duplication are lost.

Figure 8 represents the relative costs of synchronous mill type motors. The actual costs of a motor may vary with our national economic situation. Furthermore, special features or modifications are required for some installations. Thrust bearings may be required on some motors and not on others. Enclosures for ventilation may vary. These curves are, therefore, based upon open normal design motors. They represent relative values only and are intended to be used only as a guide in the selection of motor speeds, gear ratio, etc.

A 4000-hp synchronous motor for a roughing mill, for example, may cost 50 per cent more when rated 150 rpm than when rated 400 rpm. If the cost of one motor rating is known, then it is easy to estimate the dollar difference for comparison with some other rating. This difference could be a worthwhile consideration in gear ratio selection. The actual gear ratio limitations and costs must be compared with motor costs to make an intelligent selection.

A similar comparison can be made for d-c motors. For example, in Figure 9, a 2500-hp motor at 80 rpm may cost 50 per cent more than 2500 hp at 150 rpm. The dollar content of this difference in motor ratings would certainly influence the choice of gear ratio.

The d-c mill type motor for hot mill application in general has a 2 to 1 speed range by motor field adjustment. There are design limitations both in the actual speeds which can be made available and in the speed range permissible for a given design. Even if design

TABLE III

Ratings for Metal Rolling Mill Motors — 600 Volts D-C

Hp	Base speed, rpm																							
	1150	850	690	575	500	450	400	350	300	250	225	200	175	150	125	110	100	90	80	70	65	60	55	50
	Speed by field control, rpm																							
250	1800	1800	1800	1800	1675	1620	1570	1460	1340	1200	1130	1050	965	860	760	700	650	....	....	....	....	....	....	....
300	1800	1800	1800	1720	1600	1570	1500	1390	1280	1160	1085	1010	930	825	730	675	625	....	....	....	....	....	....	....
350	1800	1800	1750	1650	1540	1500	1430	1340	1230	1110	1040	965	895	800	710	650	610	....	....	....	....	....	....	....
400	1800	1770	1690	1590	1480	1440	1390	1290	1200	1075	1010	940	860	775	680	635	590	....	....	....	....	....	....	....
500	1800	1670	1590	1480	1400	1350	1310	1210	1120	1020	950	880	820	735	650	600	565	525	....	....	....	....	....	....
600	1710	1590	1500	1410	1320	1280	1220	1130	1060	965	905	840	775	695	620	575	535	505	470	....	....	....	....	....
700	1630	1510	1420	1350	1260	1210	1160	1085	1010	915	860	805	740	670	600	550	515	490	455	410	....	....	....	....
800	1560	1460	1330	1290	1215	1160	1110	1030	960	880	825	770	710	645	575	530	500	470	435	400	370	350	....	....
900	.....	1400	1310	1225	1165	1110	1060	1000	930	850	800	745	685	620	555	515	480	450	420	390	360	335	310	....
1000	.....	1330	1260	1185	1120	1080	1025	960	900	820	765	720	660	600	540	500	470	435	400	375	350	325	300	275
1250	.....	1210	1140	1090	1040	1020	1000	875	825	765	715	670	615	560	500	470	450	410	385	350	325	300	285	265
1500	.....	1100	1050	1010	950	920	870	820	765	700	670	625	580	525	475	440	415	385	365	335	310	295	270	255
1750	.....	1030	980	960	885	850	810	755	720	660	620	585	550	500	445	415	395	365	350	315	295	275	260	240
2000	.....	.....	910	905	900	800	755	720	670	625	590	555	520	475	430	395	370	350	330	300	285	265	245	235
2250	.....	.....	855	840	785	750	715	670	635	585	560	525	490	450	405	380	360	335	320	290	270	255	240	230
2500	.....	.....	.....	790	740	710	665	635	600	550	530	500	465	425	390	365	345	325	300	280	260	245	235	220
3000	.....	.....	.....	.....	660	635	590	565	540	510	485	460	430	390	360	340	325	300	280	260	245	230	220	210
3500	.....	.....	.....	.....	.....	570	530	515	490	460	445	430	395	365	335	315	300	285	265	240	230	220	210	200
4000	.....	.....	.....	.....	.....	.....	480	465	450	420	405	395	370	335	310	295	285	270	250	230	220	210	195	185
4500	.....	.....	.....	.....	.....	.....	.....	420	410	390	375	355	340	320	295	280	270	250	235	220	205	195	190	180
5000	.....	.....	.....	.....	.....	.....	.....	.....	370	360	350	340	320	300	280	265	255	240	225	210	195	190	185	175
5500	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	300	280	260	250	245	225	215	195	190	180	175	170
6000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	285	265	250	240	230	215	205	190	180	170	165	160
7000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	240	230	220	215	195	185	175	165	160	155	150
8000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	210	200	190	180	170	160	155	150	145	140

Hp	Base speed, rpm		
	140	130	120
	Speed by field control, rpm		
7000	236	232	205
8000	220	215	205

limitations permit speed ranges of 2½ to 1 or 3 to 1, there is a price addition in the order of 3 to 5 per cent respectively for them. It is possible for conditions to arise where a great saving can be made by using a motor with one of the higher speed ratings, (with very little speed range by motor field control) and obtain the low speed operation with reduced armature voltage. This is most apt to occur where actual hp requirements fall off with speed. Special attention should be given to this possibility when separate generators or rectifiers for each motor are used.

Table III shows a tabulation of motor ratings suggested for standardization by the National Electrical Manufacturers Association. These are ratings with mill type features usually found desirable for hot strip mill main drive motors. For each base speed motor rating, there is a specified maximum speed obtainable by motor field weakening. While other special ratings may be built, this tabulation will serve as a guide to normal motor design limitations. It will be noted that the 6000-hp motor is available at 150 rpm base speed.

When selecting finishing mill speeds, a "speed cone" chart like that shown in Figure 10 should always be made. Here the stand speeds required for the specified elongations of two schedules are shown by dotted lines. Actually the finishing mill motor horsepower selected for rolling 0.05-in. strip would also roll 0.15-in. material about 1600 fpm. The roughing mill or a reheating furnace may not be able to maintain such a rolling rate so there should be some consideration given to this in selecting the actual mill drive speeds. In this case, most of speed margin is on the lower side.

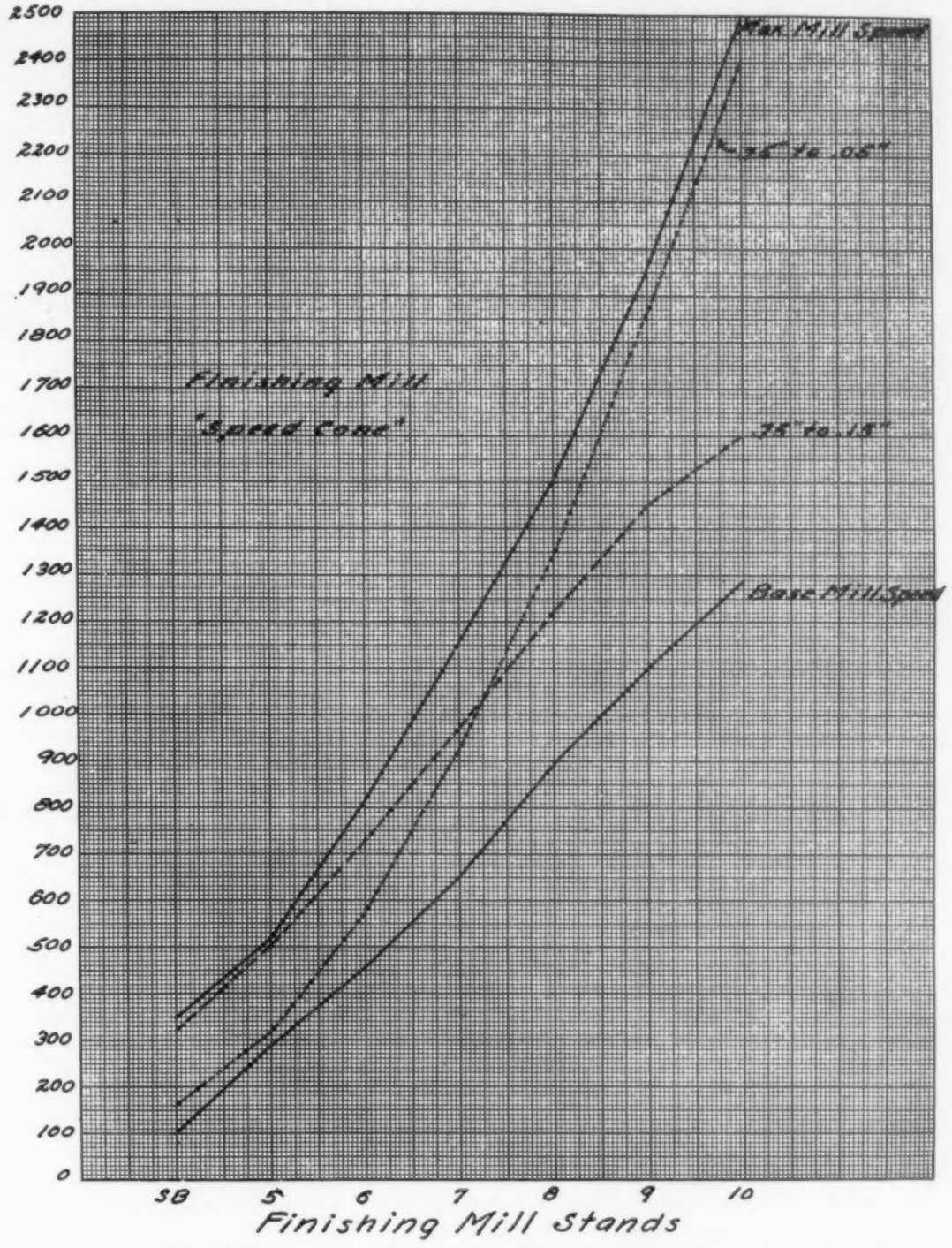


Figure 10—Chart gives a typical mill speed cone.

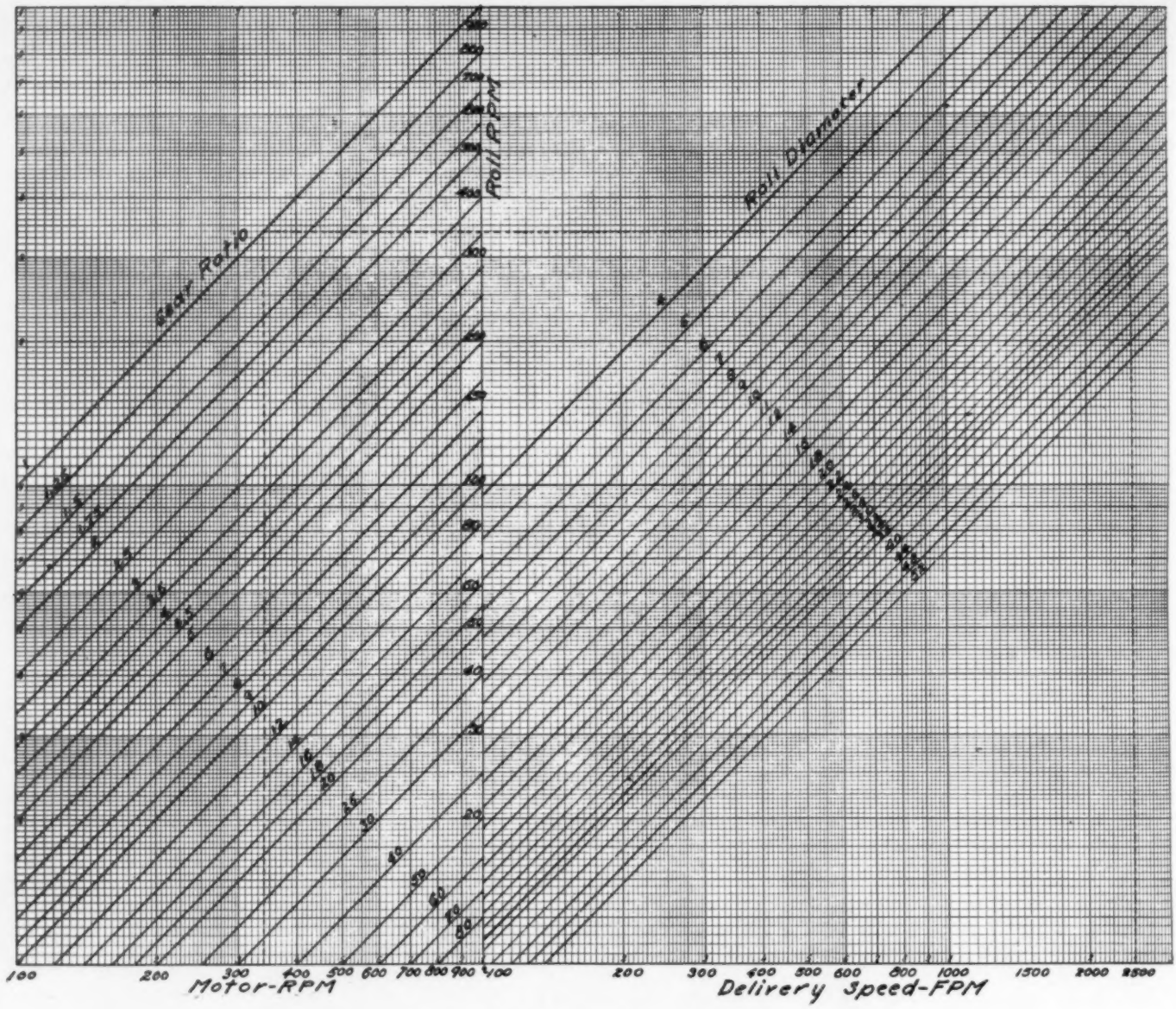


Figure 11 — Chart gives motor speed and mill speeds for various gear ratios and roll diameters.

The solid lines are drawn to show the available speed range after a final selection of motor speeds and gear ratios is made.

Some margin must also be available for roll wear and vernier speed control, etc. Stand 10 is usually fitted with rolls having the least amount of wear, and it is not likely that the driving motor be required to operate above that speed corresponding to the maximum with the largest diameter of rolls.

The scalebreaker should be provided with a little extra speed margin on the high side so that it can share some of the No. 5 stand elongation.

With the limitations of motor design, costs, etc., in mind, it is convenient to make use of a chart like Figure 11 for the selection of motor speeds, gear ratio and mill roll diameter. From this chart, for 2500 fpm using 28-in. diam roll (stand 10), it is apparent that a direct connected motor should have a speed range of 175/340 rpm. Referring back to Table III, a 4000-hp motor (as selected in the above calculation) with this speed range falls within good motor design limitations. Similarly, for stand 9 from speed cone Figure 10, a 1100/1950 fpm speed range is required. A 28-in. diam roll must rotate at 150/265 rpm. Table III indicates that this speed is also possible for a 6000-hp motor. Since it is desirable to duplicate motors where possible—motor speed for stands 5-6-7-8 and 9 should be studied simultaneously.

Table IV gives the motor ratings and gear ratios which might be considered for rolling schedules previously noted.

POWER SUPPLY REQUIREMENTS

The roughing mill motors are supplied with power from the main a-c distribution system, usually at 6900 volt or 13,800 volt levels. The actual energy used in the roughing mill will vary with each installation and with operating condition. However, it is believed that for a mill with synchronous motors, and perhaps a wound rotor roughing scalebreaker, the energy consumption of the roughing end will not exceed 13 kwhr per net ton rolled.

When wound rotor induction motors are used on the roughing stands for passes of short duration, flywheels

TABLE IV

Tabulation of Calculated Motor Speeds and Gear Ratios

Mill stand	Motor hp	Strip fpm	Roll diam, in.	Roll rpm	Gear ratio	Motor rpm
SB1	800	190	38	19.1	7.85	150
R1	4000	190	38	19.1	23.6	450
R2	4000	225	38	22.6	19.9	450
R3	5000	320	34	35.9	12.5	450
R4	5000	450	34	50.6	8.9	450
SB2	500	100- 350	26	14.7- 51.5	13.6:1	200-700
F5	5000	290- 515	28	39.7- 70.3	3.8:1	150-265
F6	6000	458- 810	28	62.5-111	2.4:1	150-265
F7	6000	650-1150	28	88.5-157	1.7:1	150-265
F8	5000	850-1500	28	116 -205	1.3:1	150-265
F9	5000	1100-1950	28	150 -265	1:1	150-265
F10	4000	1280-2500	28	175 -340	1:1	175-340

and slip regulators are quite desirable. The slip regulator serves to increase the secondary resistance of the motor, thereby permitting the motor to slow down and make use of the flywheel stored energy during the short rolling pass. This arrangement greatly reduces the power peaks from the power system.

The finishing mill motors are usually supplied at 600-700 volts d-c. The energy consumed in the finishing train will likewise vary with each installation and the type of conversion equipment used. About 35 kwhr per net ton rolled appears to be a reasonably safe value for estimating purposes. This is based on an average 0.75 to 0.085 in. reduction.

The ever-increasing demands to lower the ratio between theoretical capacity and the actual net tons rolled tend to require generating capacity more nearly equal to the connected motor load. The diversity factor usually associated with a common bus supply to all finishing stand motors is therefore approaching unity. The main single advantage of the common bus system is rapidly disappearing in favor of the many more increasing advantages of the split bus system or an individual power supply for each stand.

In the above example, there is a total connected motor load of 31,500 hp on the finishing train. This is equivalent to 25,200 kw load and could be supplied by three motor-generator sets, each with two 2400 and two 2000-kw generators or six rectifier units, two 4800 and four 4000-kw. Either of these conversion equipments could be arranged for a common bus system, a 3-section bus split, or individual power supply to each mill stand. The finishing mill scalebreaker motor would be operated in parallel with the first finishing stand motor.

Previous AISE papers have compared motor-generator set power supply with rectifier power supply. Further comment will not be made here.

There is one particular advantage of an individual power supply for each stand which should be well understood. It provides a means to regulate motor voltage as well as motor speed independently of the other stands. Fluctuating loads on one stand do not therefore cause reflections in voltage or speed of the other stands. Neither the common bus nor the split bus arrangement has this advantage. It is a very desirable feature to have when the mill is operated with strip tension between stands, especially if the tension is used to provide some control of gage or strip width.

MILL SPEED REGULATION

The speed regulation, at full load normal voltage, of a normal design direct-current rolling mill motor, 5000 hp and below, is not more than 2 per cent at maximum speed. At base speed, it is not over the product of 2 per cent and the ratio between maximum and minimum speeds. For example, a motor with 2 to 1 speed range would have not over 4 per cent regulation at base speed.

The speed regulation, at full load normal voltage, of motors rated 5500 to 8000 hp will have the values given above, multiplied by the following factors:

Ratings above 5000 hp, above 100 rpm.....1.5

Ratings above 5000 hp, 100 rpm and below.....2.0

Special design motors with improved speed regulation characteristics can be built when required.

Some mill operators have, in the past, desired motors with a speed droop and some have requested means for manual adjustment of the droop. There now appears to be increasing demands for better speed regulation. These demands are usually associated with schemes to improve gage control or width control.

The peak capacity of a motor must be considered when used with control schemes to improve speed regulation or to obtain a very rapid rate of response to vernier speed adjustments. Normal design motors have a momentary peak capacity of 200 per cent. This is the intended circuit breaker setting. It is the limit which should be used for the combined peak rolling load and that needed for speed regulation. This limit applies when speed regulation is accomplished by either motor field adjustment or armature voltage control.

VENTILATION

The electrical equipment required for a modern strip mill is not yet 100 per cent efficient and means must be provided to remove the electrical losses. This is done by blowing clean air through the equipment at the rate of 120 cfm per kilowatt loss. The loss laden air is then either discharged to the atmosphere outside the motor room or recirculated through water coolers. Approximately, 0.8 gpm of water for each kilowatt loss are required to maintain a 10 F temperature differential between incoming water and outgoing air. For a 25 F temperature differential 0.5 gpm are required.

Very often the capacity of a ventilating system necessary to absorb the losses and supply clean air to

hot mill motor equipment is not fully appreciated. The available air supply is usually contaminated with metallic dust and corrosive fumes so that the air must be filtered. Much has been written about the efficiency of various types of filter equipments. There is one universal complaint on all of them. They get dirty. Not enough has been done about efficient methods for removal of the collected dirt.

Mr. S. L. Jameson presented a paper on ventilation of steel mill equipment to the Association of Iron and Steel Engineers this year. His paper describes the various types of ventilating systems, filter equipments, maintenance problems, etc., and it should be noted as an excellent reference in the selection of hot strip mill ventilating equipment. See "Ventilation of Steel Mill Equipment," 1955 Proceedings AISE.

The following is an estimate of the ventilating air requirements for a typical hot mill motor room:

	Cfm,
Scalebreaker No. 1—800 hp—150 rpm	4,500
Roughing mill No. 1—4000 hp—450 rpm	13,000
Roughing mill No. 2—4000 hp—450 rpm	13,000
Roughing mill No. 3—5000 hp—450 rpm	16,000
Roughing mill No. 4—5000 hp—450 rpm	16,000
Scalebreaker No. 2—500 hp—200 rpm	4,000
Finishing stand No. 5—5000 hp—150 rpm	25,000
Finishing stand No. 6—6000 hp—150 rpm	30,000
Finishing stand No. 7—6000 hp—150 rpm	30,000
Finishing stand No. 8—5000 hp—150 rpm	25,000
Finishing stand No. 9—5000 hp—150 rpm	25,000
Finishing stand No. 10—4000 hp—175 rpm	20,000
Finishing mill motor-generator sets, three 12,000-hp—514 rpm	300,000
Edger drive motor-generator set—1500 hp—700 rpm	15,000
250-Volt constant potential supply, (two 1500-kw sets)	42,000
	578,500
Make-up air 10 per cent	57,500
Total	636,000

SUMMARY

There is much other electric apparatus which must be selected to properly equip a modern hot strip mill. Great improvements in hot mill operations today come from a multitude of little contributions by the various components. It is a huge task to include all items of interest in a single paper. An attempt has, however, been made to cover some of the main problems associated with the main drive equipment.

The example used illustrates the importance of proper choice of equipment, the need for a study of the drafting for each schedule to obtain optimum performance, and the greatest return on the investment.

BIBLIOGRAPHY

1. "*Determination of Motor Capacity for Main Roll Drives*," by H. A. Winne, 1932 Proceedings AISE.
2. "*Power Consumption of Hot Strip Mills*," by W. M. Ballinger and T. R. Rhea, 1941 Proceedings AISE.
3. "*Selection and Analysis of Regulating Systems for Mill Drives*," by W. E. Miller and F. S. Rothe, 1952 Proceedings AISE.
4. "*Electric Systems for Hot Strip Mills*," by R. E. Marrs, 1954 Proceedings AISE.
5. "*Electric Systems for Main Drives*," by W. E. Miller, 1954 Proceedings AISE.
6. "*New Concepts in Drive Systems for Hot Strip Mills*," by H. N. Snively and R. J. Moran, 1955 Proceedings AISE.
7. "*Ventilation of Steel Mill Equipment*," by S. L. Jameson, 1955 Proceedings AISE.

DISCUSSION

PRESENTED BY

E. H. BROWNING, Manager, Metal Working Section, Industry Engineering Department, Westinghouse Electric Corp., East Pittsburgh, Pa.

C. L. SQUIER, Assistant to Superintendent, Electrical Department, Lackawanna Plant, Bethlehem Steel Corp., Lackawanna, N. Y.

D. C. McCRADY, Superintendent, Electrical Department, The Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada.

R. E. MARRS, Steel Mill Engineer, Systems Application Engineering Section, General Electric Co., Schenectady, N. Y.

E. H. Browning: As the author indicated, all of the empirical information covered has been available in one form or another for quite a long time. Much of it dates back to the early days of electrification of mill drives. Mr. Marrs has attempted to place it in such form as to permit easier interpretation in its application in selecting mill drive ratings. Such papers are always of a nature to stimulate thinking along the lines of the considerations involved in the selection of very expensive drive equipments for hot strip mills. Some caution, however, must be exercised in using power data and consideration must be given to the conditions attending the data collection.

With regard to systems arrangements utilized for hot strip mills, much has been done to improve them. It certainly has come to pass that individual power supply arrangements are being given the bid today. Thus, the hot trip mill is following along the same line as the cold mill. Such schemes permit greater operating versatility and provide means for widening the speed cone to make a given mill more flexible in treating the processing of wide schedule variations.

The individual power supply forms give other advantages such as reducing fault current magnitudes and lessening transference of loading effects from one drive to another.

C. L. Squier: The author speaks of the several advantages of having individual power supply for each stand in the finishing train. In addition to the advantages mentioned by Mr. Marrs, the individual power supply limits the high currents which are available when faults occur on a common bus system.

The 79-in. wide hot mill at Lackawanna was built in 1935 and modernized in 1950. Part of the modernization program included addition of a seventh mill stand. At this time a 4000-kw rectifier was added to the finishing stand bus, it was to operate in parallel with the two 6000-kw motor-generator sets and a 4000-kw motor-generator set. The rectifier was connected to the existing bus with $7 \times 7 \times 5/16$-in. square ventilated copper bus, supported on insulators designed to give the mechanical strength required to withstand the stresses which might occur with a fault on the system.

The ventilation system of the hot mill motor room certainly presents many problems. The author mentions the ventilating system where air is recirculated

and cooled by passing the air through surface type coolers. Most systems of this type have no filter media in the recirculated air duct. As the carbon brushes of the motor and generator wear away, they deposit quantities of highly conductive material on the machine windings and also deposit dirt on the fins of the surface coolers reducing the efficiency of these units.

The addition of a filter in the recirculated air duct would reduce maintenance problems on the air coolers and machine windings.

D. C. McCrady: One question is on the stipulation that on roughing stands, passes of over five seconds do not warrant the use of an induction motor and flywheel. I would like to know the derivation of that statement.

Mr. Marrs mentioned the difficulty of the different types of air cleaners, particularly on make-up air systems. I entirely agree with Mr. Marrs that no satisfactory air cleaning device has as yet been marketed. We have tried oil screen filters, air washers, precipitation, throw-away filters, and combinations of various of these, with questionable results.

I would like to mention our latest installation, which is of an experimental nature, used on a continuous annealing line, the size of the equipment being quite small. It consists of a somewhat conventional traveling screen oil filter, with modifications. The modification embodies a series of jets which force clean oil against the screen just before it emerges from the bath. Oil from the bath is recirculated through a filter, resulting eventually in a filter cake being deposited on a discardable roll of heavy paper. The returned oil is directed under pressure against the screen in an effort to dislodge accumulated dirt.

This installation has only just gone into operation and I cannot vouch for its effectiveness. Possibly someone here may have had some similar application and if so, I would appreciate hearing of their results.

The idea, of course, is to dispose of the collected dust and dirt in a manner not too distasteful to the steel mill maintenance staff. If this result is effected, possibly these filters will be maintained.

R. E. Marrs: Mr. McCrady asked about the derivation of the statement that roughing mill passes of five seconds or more do not warrant the use of flywheels and wound-rotor motors. This is based on the relative horsepower-seconds that must be supplied by the motor and flywheel during a pass. If the rolling power contribution of a flywheel in slowing down must be maintained over a period of five seconds or more, the size of the flywheel required results in a drive more costly than a synchronous motor drive of equal torque capacity.

There have been cases where three seconds appeared to be the maximum limit, but I think five is more often the maximum. A study would have to be made of each application to evaluate the use of flywheel exactly.

With reference to comment on air filter equipments, there appears to be an increasing interest in the use of throw-away filter media in both recirculating systems and particularly in non-recirculating systems in series with an electrical precipitator type. The fine dirt particles are agglomerated by the electrical precipitator and the large dirt particles which either pass through or are discarded by the electrical precipitator are then collected in the throwaway filter media. This type of equipment appears to have a very promising future.

AISE Establishes Scholarship

▲ THE Association of Iron and Steel Engineers recently established a scholarship plan for students who want to study engineering. It will be known as the Association of Iron and Steel Engineers Merit Scholarship and will be administered by the National Merit Scholarship Corp. in Evanston, Ill.

A four-year scholarship will be awarded annually to a boy who meets the requirements and who wants to take mechanical, electrical, metallurgical, civil or chemical engineering in a school of recognized standing. The amount of financial aid will depend on need. The minimum stipend will be $100 a year; the maximum will cover the full cost of attending the institution selected.

In every case, a supplementary grant-in-aid will be made to the college.

All operation of the scholarship program will be carried out by the National Merit Scholarship Corp., who invite the more than 24,000 secondary schools in the country to participate each year by selecting the outstanding five per cent of their senior classes as available candidates. These students are then screened and tested, and final selections are made.

The National Merit Scholarship Corp. is an independent, non-profit organization designed to administer a nation-wide system of scholarships for higher education. Its administrative expenses are taken care of by grants from the Carnegie Corp. and the Ford Foundation. A fund of $8,000,000 is earmarked for matching scholarships, so that the effect of a sponsor's grant is doubled. In addition, the organization has $10,000,000, to be used at the rate of $1,000,000 a year for sustaining scholarships.

In selecting National Merit Scholarship Corp. to handle the new scholarship program, AISE has followed the example of a considerable number of business and industrial concerns who have already sponsored Merit scholarships of their own, thereby relieving themselves of the task of administering their programs.

AUTOMATIC

▲ IN recent years, the electronic scale has been put to an ever increasing number of uses in basic steel production. This paper will outline the basic components, and their adaptation to the problem of data transmission and recording.

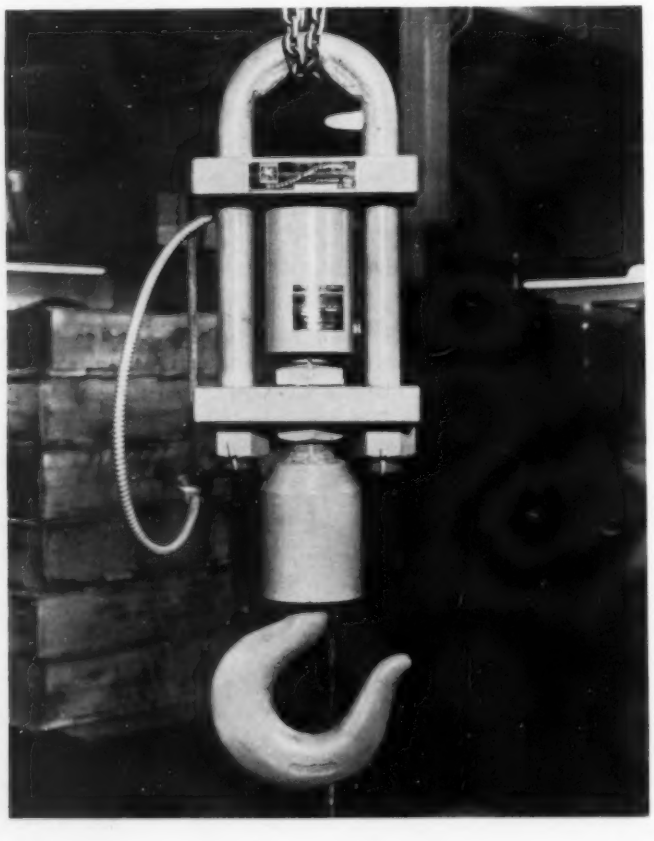
Basically, the electronic scale comprises three basic elements. They are the transducer, which in most cases is a load cell, the servo system, and a readout device, designed for the particular application.

Transducers—This discussion will explore only the use of the load cell. The load cell consists essentially of a calibrated steel column, with four strain gages bonded to the sides of the column and encased in a hermetically sealed container. The strain gages are connected electrically in the form of a wheatstone bridge. Two diametrically opposite corners of the bridge are connected in series with the input terminal of the load cell. The other two diametrically opposite corners serve as the output terminal of the load cell. Following Hooke's law of proportionality between stress and strain, electrical resistance of strain gages changes in proportion to deflection of the load column. When force is introduced on a load cell, strain gage output voltage is fed to a balancing bridge arrangement, which is the wheatstone bridge mentioned above, formed by the series connection of the four strain gages. Since the system is initially in electrical balance, the introduction of voltage across one leg of the bridge brings about an unbalanced condition. This difference represents weight of the object on the scale. Figure 1 illustrates the load cell and its construction.

Servo system—The servo system measures the load cell output voltage by comparing it with a reference a-c voltage. Major components of the servo system are a balance bridge, an amplifier, a two-directional servo motor, and a zero adjust bridge. Initially, with no load on the load cell and, therefore, zero output voltage, the system is at zero balance. However, if a load is then placed on the load cell, the load cell output voltage increases a corresponding amount and a finite portion of this voltage appears across the amplifier input terminals. The amplifier amplifies the impressed voltage considerably, and then directs it to the servo balance motor. The servo motor, as a result, starts to operate and drive through a mechanical gear system both the rotary precision potentiometer in the balance bridge and the movable element of the data presentation device—that is, in this latter case, the pointer of a dial, digit wheels in a printer, etc. Due to the adjustment of the precision potentiometer, a portion of the reference voltage appears across the balance bridge. This resultant voltage across the bridge is in opposition to the load cell voltage, and progressively increases in value as long as the servo motor continues to drive the potentiometer slider away from its original position. The servo motor continues to run until the balance bridge opposing voltage is equal in magnitude to the load cell voltage. The motor then stops because the two voltages have cancelled one another out, leaving zero voltage impressed across the amplifier input terminals, or zero power to further drive the motor. This constitutes a balance point for the system and it will remain as such until the load cell voltage is changed. Since the servo motor, the precision potentiometer, and the data presentation device all work in synchronism with one another, the weight represented by the load cell voltage has also been positioned on the data presentation device and may be immediately printed or visually read out. When the weight is removed from the load cell, the system reverses the above procedure and returns to a normal zero balance position.

The zero adjust bridge is used to bring the recorder to a proper zero balance. This device consists of a separate voltage source and a potentiometer which serves as a voltage divider for the voltage source. The adjustment of this potentiometer permits one to obtain a proper zero balance of the recorder by producing a voltage which is equal and opposite to an undesired voltage in the measuring circuit. Also, any slight zero shifts which might then occur due to temperature variations or other causes can be readily compensated by adjusting this control. In many cases this control is used to cancel out the voltage due to a weighbridge

Figure 1 — Load cells were quickly attached for use with crane hooks.



WEIGHING IN THE STEEL INDUSTRY

Possibilities of electric weighing have only been scratched and its usage will expand many times as the imagination and ingenuity of engineers are applied to the problem . . . flexibility of equipment eliminates many of the limitations imposed by mechanical systems.

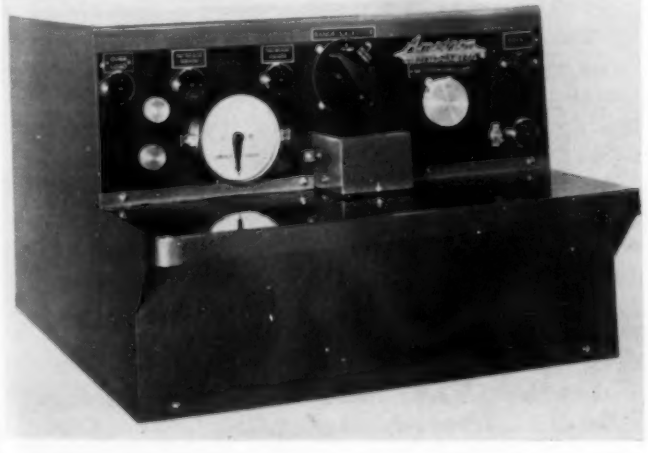
By ROBERT A. VOLL
Western Branch Manager
Streeter-Amet Co.
Los Angeles, Calif.

or other form of load receiving element on the load cells.

If tare weight compensation is desired in a scale, a device similar to the zero adjust control, consisting of another separate voltage source and potentiometer, is incorporated into the servo system. However, in this case the potentiometer is varied by means of a hand dial calibrated in weight units. The dial is set to the indicated tare weight for each load. For example, if a box having a known tare weight of 500 lb and containing several castings is placed on the scale and only the weight of the castings is desired, the tare weight compensating dial is set to 500. At this setting, the tare weight potentiometer produces an opposing voltage which cancels out the portion of load cell output voltage due to the weight of the box. The servo system therefore detects only the portion of the load cell output voltage due to the castings, and as a result, the weight of the castings alone is readout by the data presentation device.

Data presentation—Since the angular displacement of the servo motor shaft is proportional to the applied weight, it may be utilized to mechanically position data presentation elements such as the pen of a strip chart, the pointer of a visual dial, geneva pinion interconnected visual digit wheels, and/or the printing mechanism of a recorder. A group of step cams, geared to the servo motor, are rotated to a corresponding position whenever the servo system seeks out a null balance point for a weight. Then once the servo motor has brought the step cams to a standstill balance position, the sensing fingers move forward from their waiting positions and engage the cams. The length of travel of each finger depends on the depth of the particular step alined in front of it, while the depth in turn corresponds to a certain digit. As each sensing finger moves forward, its attached rack meshes with the pinion of its associated typewheel and rotates the wheel to a printing position corresponding to the digit being detected on the step cam. Once all of the typewheels have been positioned in this manner, the print hammer snaps down and records the value of the weight on a card or tape held immediately above the typewheels. The sensing fingers then move back to their waiting positions until the next weight is to be printed. See Figure 2.

Figure 2 — Ease of recording is a feature of electronic weighing equipment.



BASIC STEEL APPLICATIONS

It is safe to say that a major portion of electrical weighing development has come about as a direct result of the steel industry. Since the invention of the word and processes now called automation, automatic weighing has become increasingly important.

Figure 3 — One method of transmitting data is through telemetering units.

The following outlines a program now in the process of surveying. It involves a large steel company and its integrated sheet and tin mill.

To supply a bit of background to this program, some history will be reviewed. Prior to World War II, a steel plant would be proposed for a given location. All of the intricate engineering was done to the finest detail. Somewhere along the line, someone would suddenly think of a scale. This would be put in at a point usually not convenient to anybody and not designed to do a complete job. In other words, it was relegated to a necessary evil. This picture has changed. Many things have contributed to this change.

1. The need for more complete data.
2. The increased use of automatic computers.
3. The ever expanding number of persons requiring this data.
4. The extreme diversification of the steel industry.

All these, and more, have brought about the need for automatic data and weight determination.

To return to the original subject of the survey now being contemplated, the following represents the ultimate goal. In the average sheet and tin mill there are about 25 weighing points, all of which require personnel to operate. Through the use of electrical scales, the weighing operation can be made completely automatic. In addition to printing or indicating the weight

Figure 4 — Recording weight on crane hook is done by unit shown in circle.

for immediate usage, the recorder will also code the data and reproduce its value either on five-channel punch paper tape or punch cards.

Here another personnel heavy area is reached. Now, all weight data has to be manually transcribed on several forms and ledgers. The final results of production are not known for some time as a result of this hand posting. However, as just mentioned, all of the data has been reduced to a mechanized form, and a vast number of computer mechanisms are now available to reproduce this data on large ledgers and do it in a very few minutes.

There is one further step that can be made. That is to bring all of this data, whether it be weight information or production counting to a central point on the mill floor. This opens up the ever expanding field of data transmission. Remembering that all of this data is available in either electrical or mechanized form, it is now possible to relay it to a remote point. It is well within the realm of possibility to have all production data brought to a large console cabinet, centrally located and operated by one or two highly trained individuals. The forms of data transmission are quite varied. It can be accomplished by telemetering, or carrier wave or direct pulsing. See Figure 3.

The above, of course, is the ultimate, to emphasize the ever increasing number of uses and the ever increasing research now being carried on.

To further explore the vast number of uses to which electrical scales are being put, a very popular one, will be described, the crane scale. Most operators have had experience with the cumbersome mechanical type. This type rarely enjoyed much popularity for several reasons, the most important being inaccurate weights. Maintenance was also a severe deterrent to their use. The electrical scale changed the thinking on crane scales. As already mentioned, the weight data is measured in an electrical form. Therefore, to indicate this value, a flexible electrical cable is all that is required. This form of weighing will be installed very shortly in a plant coupled with the transmission of the data via telemetering to a remote point on the mill floor. Figures 4, 5, 6 and 7 show various applications and components.

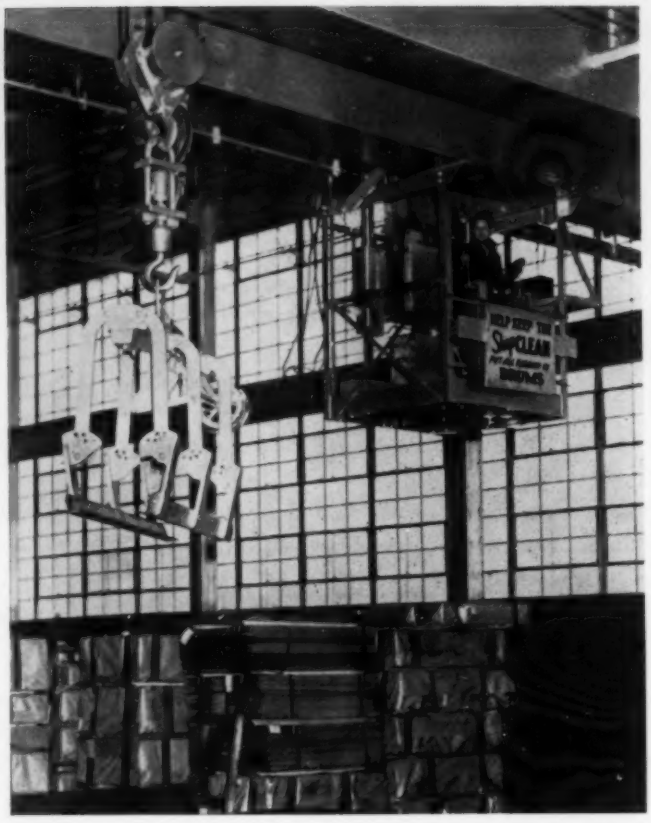


Figure 5 — Electronic scale devices on cranes eliminate one handling step.

Figure 6 — Electronic devices are being installed on truck scales.

Figure 7 — Automatic records can be obtained on railroad track scales.

ELECTRICAL SCALE LIMITATIONS

Like everything else, the electrical scale has its limitations. Notwithstanding the fact that load cells are hermetically sealed and can be subjected to oil, water, and dirt, they do have their limiting factors. The most serious are temperature, shock, and eccentric loading.

The effects of temperature can be offset by lagging cells with insulating materials to reduce the rate of heat transfer. Radiation shields also are used. In extreme cases, cooling with air or water is possible.

The effects of overload are as follows: Cells have no moving parts, but they can be damaged. Cell damage or zero shifts are not caused by loads up to 120 per cent of capacity. Because cells have high response speed, they react to shock loads, which should not exceed 120 per cent of capacity. Overloads of 150 per cent of capacity may cause a slight zero shift. Damage results if such loads are frequent.

Normal loads exert their force on the center axis of cells. Eccentric loads, which are perpendicular to the center axis, should not exceed 25 per cent of rated capacity. This type of load will introduce serious error.

SUMMARY

Electrical scales are available for all classes of weighing. The flexibility of the equipment and associated instrumentation removes most of the limitations imposed by mechanical systems. Electrical weighing is proven in the field and is accepted by industry and commerce.

The possibilities are only scratched. Imagination and ingenuity by the engineers in industry will expand their use many times.

Electrical weighing may well be accepted into the instrumentation family and become a primary tool of the instrument engineer.

Are you annoyed by having someone borrowing your magazine when you want it? Get him to join the AISE.

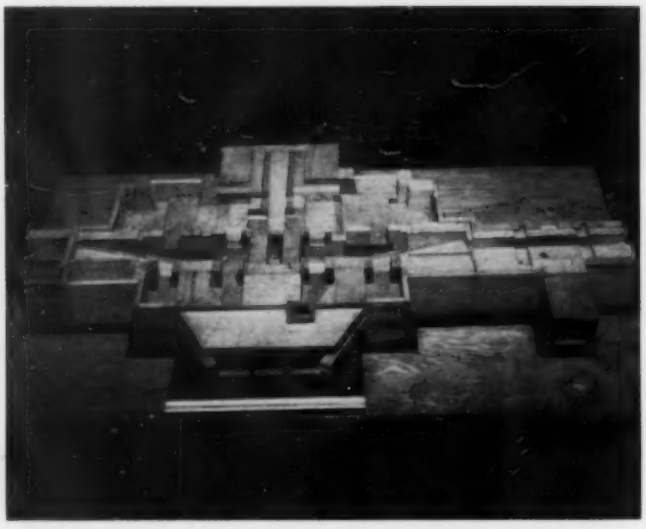


Figure 1 — The model of the old foundation helped to plan the job.

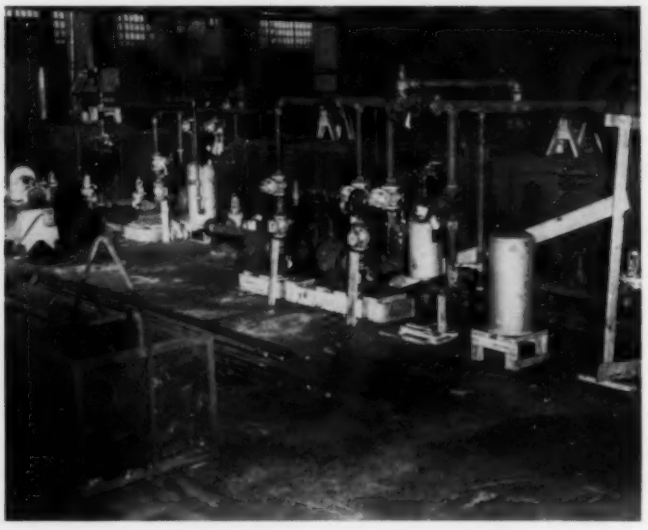


Figure 2 — Oiling systems were preassembled in advance in a different part of the plant.

REPLACEMENT

▲ INLAND'S No. 2 blooming mill was placed in operation in March, 1917. It was a 40 x 90-in. mill designed for 8-ton ingots. There had been little or no change or replacement of fundamental equipment in the mill since its installation. The mill had rolled more than 27,000,000 tons of sheared products in that time. Originally, the product of the mill was essentially blooms for rails and structurals, 14-in. mill billets and 26-in. wide plate mill slabs, all rolled from 27⅜-in. ingots and all in the medium and higher carbon ranges with a maximum 8-ton ingot weight. Ingot weights and sizes had increased and the character of the product had changed considerably since the advent of the strip mills. Formerly ingot heating was much simpler in that lower temperatures could be used, uniform heating more easily attained and pit capacity was relatively greater. There was no hot topping with its attendant cold delivery, the flow of steel was more regular, and delivery was faster.

The advent of the strip mills brought about wider and heavier ingots in the low carbon ranges, higher rolling temperatures, more pit cinder and scale, more difficult heating, and added burden on the equipment generally. Many years of repeated impact, manipulation and transport of the product beyond the originally intended load had taken its toll.

The practices and trends of the steel supply adversely affected this mill. Extended operations at the No. 3 blooming mill took the greater share of the hot steel supply available at particular times to suit the limits of the No. 3 blooming mill schedule. This led to bunching the No. 2 mill heats with long gaps between heats resulting in a greater portion of colder steel going into the pits. The expanded use of hot topped steel required more heating time. Increased heat sizes in the open hearth resulted in longer pouring and stripping time also contributing to cold steel.

Keeping pace with the progress of the industry, the ingot size increased to a maximum of about 12 tons which imposed considerable overload on the tables, side guards and manipulators. The demands for production and this overloading over the years led to abnormal mechanical failures and mill delays. Furthermore, much of the mill equipment was outmoded.

The mill housings were worn into the shoe plates as much as 2½ in.; the spreaders were worn into the mill housings; mill table beams were broken with bearing

Figure 3 — Pinion stand lubrication system was installed prior to the mill shutdown.

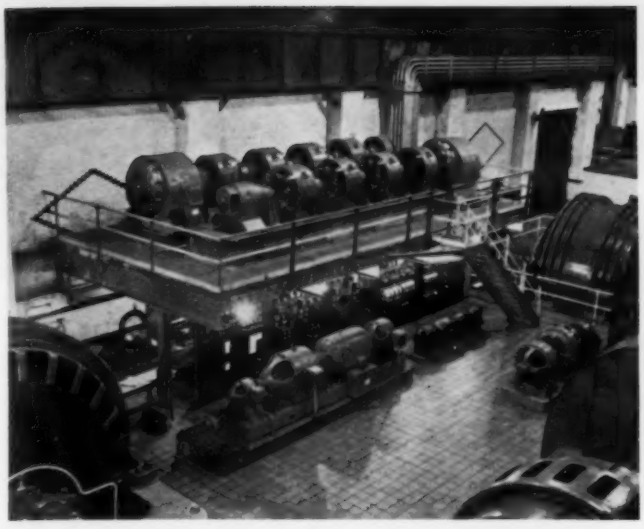


Figure 4 — Auxiliary motor-generator sets were also installed prior to mill shutdown.

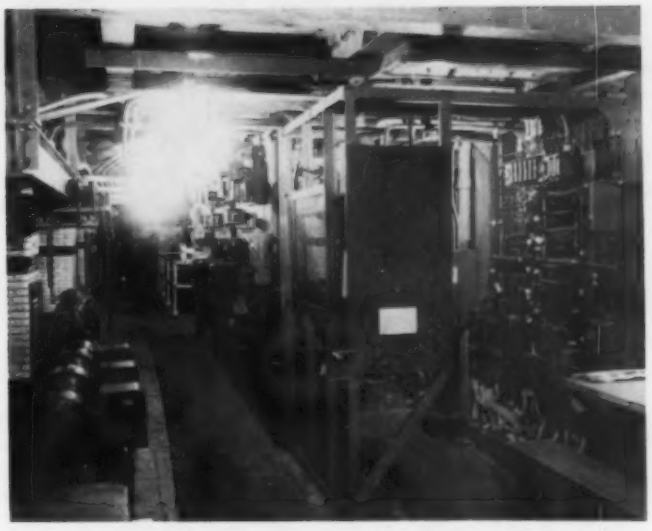


Figure 5 — Equipment shown is located underneath the auxiliary motor-generator set platform.

OF INLAND'S NO. 2 BLOOMING MILL

By A. L. SCHROEDER

Superintendent

Field Forces Dept.

Inland Steel Co.

East Chicago, Ind.

seats cracked and broken out; roll balance accumulators were badly worn and there was considerable wear on the mill housings and screw mechanisms. The general uneven settlement, with cracked and seriously eroded foundations, resulted in serious machinery misalignment difficulties, with attendant costly repairs and replacement of bushings, gears and shafting.

It was determined that the mill table and manipulators would have to be removed in order to make necessary repairs to the foundation. The mill equipment required extensive shop time for repairs and replacements. This generally deteriorated condition was true of the mill runout and shear tables, the shear, bloom and slab transfers and other mill equipment. The overall problem, therefore, included the installation of additional soaking pit capacity as well as rehabilitation of the mill and its auxiliary equipment. A study resulted in the following recommendations:

1. The installation of additional soaking pit capacity.
2. The replacement of existing batteries of small pits with larger, modern pits.
3. The installation of a modern scale sluicing and scale pit arrangement.
4. The replacement of the existing main trunk sewer which was badly overloaded.
5. The replacement of the existing electrical equipment with modern adjustable voltage control.
6. The replacement of the bloom scarfing machine with a four-surface bloom and slab scarfing machine.
7. The replacement of the entire mill and its auxiliary equipment on new foundations.
8. Due to the trend toward larger ingots and wider slabs, it was recommended that the new mill be a 46 x 100-in. mill.

The project was divided into steps:

Step 1 included a new battery of soaking pits; the replacement of an existing battery of pits; replacement of the main trunk sewer; the replacement of the mill proper up to the delivery table; the installation of a larger drive motor on the main mill motor-generator set; the installation of a rotating regulator on the main mill motor; the installation of adjustable voltage control with rotating regulator on the mill auxiliary; a new scale sluicing and collecting system; and new roll balance accumulators.

Step 2 included the installation of a second, new

Through careful planning and scheduling, Inland rebuilt its No. 2 blooming mill with total down time of 23 days and 45 minutes . . . . operation was initiated without difficulties and excellent production was obtained in a very short time . . . . practically the entire job was done with Inland's personnel.

battery of soaking pits and the replacement of a second, old battery of pits; the replacement of the bloom scarfing machine with a four-surface bloom and slab scarfing machine; replacement of the shear, tables, crop conveyor, slab and bloom transfers.

Step 1 was approved and work was started. The new No. 7 set of pits was installed after which the No. 6 battery was rebuilt. The new sewer was installed and preliminary work started on the mill proper which included the installation of the scale pit with settling basins and alternate provision for wasting or recirculating mill water.

Inland has a total of three blooming mills which meant we would lose approximately one-third of the total production while the mill was out of service. Therefore, the down-time for making the changes had to be held to a minimum. Considerable study and planning was done and the mill was scheduled to be shut down for 26 days to accomplish the work.

The preliminary work done prior to mill shutdown took advantage of the normal weekly 8 or 16-hr shutdowns which were, in some cases, combined to provide as much as 32 hours to do work such as the installation of the larger drive motor on the main mill motor-generator set.

During this period, the new motor-generator sets and control equipment were installed in the motor room for the mill and its auxiliaries; form work was preassembled; oiling systems were set up remote from the site and piped, match-marked, disassembled and packaged for reassembly; a new pinion stand lubricating system was installed and piped; the new scale pit was installed; controls were installed in the new mill operator's pulpit; sections of floor were removed; sheet piling was driven at the limits of the excavation; and as much other preassembly as was considered practical was done.

A 1200-cu ft air compressing station with 40 conveniently located connections was installed for construction; oxygen and acetylene outlets were installed at 32 convenient places; 22 switches were provided for electric welders; and since this was to be an around-the-clock operation involving night work, a completely new, permanent overhead lighting system was installed. At 8:00 a.m., on September 28, 1953, after producing 27,487,662 tons of sheared products, the mill was shutdown and construction started.

Figure 1 shows a model of the old foundation. This model was made on a ¼-in. to 1-ft scale and was used to assist the dynamiters in determining where they were to do their line drilling.

The center foreground of Figure 1 shows the old scale removal system. It consists of a three-tunnel system with railroad tracks joining into the old scale pit in the next building. The new scale pit was to go in the same location as the old pit, so large hatches were cut in the roofs of these tunnels in front of the mill and covers were made. During the time that the scale pit was being installed, it was necessary for the mill to remove the mill scale through the holes in the floor. Considerable line drilling was done at accessible places prior to the shutdown. These holes were drilled in the various tunnels and at predetermined break-off points.

The oiling systems were set up in a different part of the plant in order to do the necessary piping as shown in Figure 2. The foundations were faked and the pumps, tanks and various pieces of equipment were set up in accordance with the drawings. The entire system of piping was tested, match-marked, dismantled, pickled and packaged for later installation.

Figure 6 — A system of stenciling was set up on the equipment, listing the shop order, piece number, and weights.

Figure 3 is a view of pinion stand lubricating system which was installed, piped and tested prior to the mill shutdown. This required the removal of part of the motor room floor and removal of a large portion of the existing pinion stand foundation. A tunnel was cut into the pinion stand foundation to accommodate the new piping.

Figure 7 — A carloading schedule was set up as shown.

CONTINENTAL EQUIPMENT - CAR PRELOADINGS

CAR	TYPE	DESCRIPTION OF MATERIAL	TOTAL WEIGHT
1	Gon	Front Auxiliary Table Rolls (9 Pcs) Pc #10-18	42 tons
2	Gon	Back Auxiliary Table Rolls (9 Pcs) Pc #1-9	42 tons
3	Gon	Front Main Table Drive Girder	52 tons
4	Gon	Front Main Table Side Guards (2); Separators & Roll Gauge Assemblys (2); Separator; and Idler Girder. LOADED IN THAT ORDER	82 tons
5&6	Gon	Back Main Table (Same as Front Main Table)	82 tons
7	Gon	Mill Screwdown Equipment - Screwdown Drive; (2) Worms (Box 106, 107); (2) Spline Shaft Assemblys (Box 104, 105); (2) Screws & Nuts (Box 134) LOAD IN THAT ORDER leaving Screwdown Drive Free to be unloaded without moving other equip.	37 tons
8	Flat	Rack Base Assembly 1 Pc	52 tons
9	Flat	Rack Base Assembly 1 Pc	52 tons
10	Gon	Manipulators - (8) Rack Pans; (8) Rack Pan Covers (8) Manipulator Bars Complete; (8) Supporting Columns; (8) Bar Bumpers; (4) Rack Bumpers; (4) Filler Blocks	Approx. 50 tons
11	Gon	Back Main Table Rolls	75 tons
12	Gon	Front Main Table Rolls	75 tons
13	Gon	Housing Covers & Feed Rolls - (4) Feed Rolls Complete; 2 Housing Covers Complete	42 tons
14	Gon	Roll & Spindle Balance Equipment - Lifting Beams & Top Roll Carrier Assembly Complete; (6) Balance Rods; (1) Spindle Balance Cylinder Complete; and (2) Roll Balance Cylinders Complete. LOAD IN THAT ORDER	
15	Gon	Side Guards & Fingers - (4) Side Guards & 8 Fingers	75 tons
16	Gon	Pull Back Equipment - Pull Back Drive Bases (2); Pull Back Base; Bearings Shafts & Levers	20 tons
17	Gon	Lower Spindle Equipment; Lower Spindle Complete; Spindle Carriers with Bearings (2); Lower Spindle Carrier Beams (2); Spindle Carrier Support (1); Links (3); LOAD IN THAT ORDER	85 tons
18	Gon	Upper Spindle Equipment: Top Spindle Complete; Spindle Carriers with Bearings (2); Top Spindle Carrier Beams Assemblys; Bell Cranks Complete (2); Links (3). LOAD IN THAT ORDER	45 tons
19	Gon	Feed Roll Equipment; (4) Feed Roll Spindles; 2 Feed Roller Drive Assemblys	51 tons
20	Gon	Roll Change Buggy Complete	

The auxiliary motor-generator sets were installed prior to the mill shutdown as shown in Figure 4. The new motor-generator sets for the mill auxiliary are shown on the platform and the rotating regulator for the main drive motor is shown on the floor in the foreground. In the right background a door is shown which had been enlarged to get the mill housings in. The mill housings were brought in through the motor room. This equipment was installed and tested, circuits were faked and as much testing as practical was done ahead of time. Some of the conduits to the new mill went out overhead as shown in the background. This work was done prior to the mill shutdown.

Figure 5 is the back view of the equipment underneath the auxiliary motor-generator set platform and shows the rotating regulators for the mill auxiliaries and the control equipment. In the basement below this area, additional control equipment had been installed. This included controls for a-c motors which had been installed and tested while the original mill was operating.

Figure 6 is a view of the partially preassembled front mill auxiliary table showing the system of stenciling piece number, shop order number and weights. This system was used on all major units of equipment. We had an old mill and an old crane servicing the mill. This crane, which was a 50-ton crane, was subjected to electrical, mechanical and structural tests using test loads. As a result of these tests, it was decided to limit the load of the crane to 65 tons. Assemblies or partial assemblies such as the one shown in Figure 6 were therefore limited in weight to 65 tons.

Figure 8 — A schedule was set up outlining the supervisory personnel required on each shift.

NO. 2 BLOOMING MILL REBUILD - SUPERVISION

Department	12 - 8	8 - 4	4 - 12
Engineers	C. Lehman A. Zaversnik D. Clark G. Klippel W. Knall R. Diviak R. Youngfelt J. Welsh D. White J. Bardowski	F. Braley W. Bowman G. Lynds K. Bray F. Castillo C. Tabor F. Dunham S. Manich J. Roth B. Ray	J. Tysall H. Schneider J. Little S. Mark J. Williams W. Cooper C. Balzer J. Hodor K. Hodgers H. Springer
Machinists	H. McCoy N. Petrusic	D. Frankenhauser G. Eichelberger E. Bell N. Brown O. Ogrodowski	W. Amstein J. Guadagno
Riggers	F. Turicich M. Katusich	S. Wahlman L. Evanats J. Reed J. Jambro J. Alletto H. Johnson	J. Philpot M. Mikicich
Labor	M. Stimak W. Fiene L. Bombela	F. Frame H. Schweitzer A. Hinojosa S. Victor H. LaSalle	A. Arabia A. Vanni T. Evert
Carpenters	J. Richardson C. Hecht	C. Bray J. Winning J. Cisman G. Lynch	R. Dixon W. Prochot
Boilermakers	K. Fout F. Wolfe	G. Melvick W. Walker W. Hanley	W. Balka T. Glinski
Electricians	L. Young	W. Bierman J. Sabo K. Marshall	W. Fuller
Pipefitters	R. Bennett B. Wajek F. Tarka	C. Fryman F. Iczkowski G. Wentland A. Smith	M. Beckman M. Kasilis E. Sacsawe
Material Men	J. Sannita	C. Marsh	A. Visnisk
Transportation		C. Salter	

The mill housings were placed on skids. The housing weight of 105 tons exceeded the load limit of the mill crane. It was necessary to transport this housing through an adjoining mill building which had two 75-ton cranes and subsequently transfer it through the motor room. Using both the motor room and mill cranes, the housing was moved through the pinion stand opening and set on rails with housing feet over the mill shoes. The housings were then tilted up into position on the shoes using the mill crane and two double drum winches.

Several charts were made for planning purposes. One chart indicated the desired sequence of blasting. While planning this job, it was decided what portion of the foundation was to be removed first. Accordingly, it was arranged to have that portion of the machinery moved first. This same sort of planning was used for the excavation and form work phases of the job.

Twenty cars were pre-loaded with machinery and equipment. The schedule of cars is shown in Figure 7. This chart shows the cars in planned rotation with car numbers, description and weights of material. When this material was loaded into cars, the loads were balanced and proper sling positions were marked. In some cases, special slings and lifting devices remained with the equipment until it was installed. It was necessary to use these cars for the temporary storage of major units and assemblies of equipment due to the extremely limited storage areas available in the mill building.

Figure 8 shows the schedule of supervisors including

Sheet #10 9/14/53

SCHEDULE

PLT. #2 - NO. 2 BLOOMING MILL REBUILD

Acct. Capital 2196-252
Major Expense 2191-252

WORK DESCRIPTION	DISPOSITION	EQUIPMENT	CRAFTS & CRAFTS	START	COMPLETE	TIME
Dismantling Of Existing Equipment						
F. Auxiliary Mill Tables						
1. Scarfing Duct And Hood - Remove Scarfing Fume Removal Duct And Hood, Salvage And Reuse.	Salvage	Mill Crane	F.F.Riggers Boilermakers	8 AM 9/29/53	4 PM 9/29/53	
2. Scarfing Approach Table - Remove Scarfing Approach Table - Scrap.	Scrap	R.R.Eng.& Cars Mill Crane	Switch Crew F.F.Riggers Machinists Electricians Laborers	12 Noon 9/29/53	8 PM 9/29/53	
G. Lubricating Equipment						
1. Farval System Pump - Disconnect And Remove Farval Lubricating Pump, Salvage.	Salvage	Mill Cranes	Mill-Mech. Flt. #1 Pipe Electricians	8 AM 9/28/53	4 PM 9/28/53	
2. Farval Pump House - Wreck Farval Pump House, Scrap All.	Scrap	Mill Cranes	F.F.Riggers Laborers Boilermakers	4 PM 9/28/53	12 Midnight 9/28/53	

Figure 9 — Form illustrates dismantling schedule.

Figure 10 — Form illustrates installation schedule.

Sheet #10 9/17/53

SCHEDULE

PLT. #2 - NO. 2 BLOOMING MILL REBUILD

Acct. Capital 2196-252
Major Expense 2191-252

WORK DESCRIPTION	DISPOSITION	EQUIPMENT	CRAFTS & CRAFTS	START	COMPLETE	TIME
Installation Of New Mill Equipment						
10. Back Mill Table Manipulator And Finger Drive Equipment - Install Back Mill Table Manipulator Equipment As Outlined In Section ___ Of The Major Material And Equipment Schedule.		Mill Crane	All Field Force Crafts	Setting Time 12 Midnight 10/16/53 Assembly Time 12 Midnight 10/17/53	12 Midnight 10/17/53 6 AM 10/24/53	
11. Front Mill Table Manipulator And Finger Drive Equipment - Install Front Mill Table Manipulator Equipment As Outlined In Section ___ Of The Major Material And Equipment Schedule.		Mill Crane	All Field Force Crafts	Setting Time 12 Midnight 10/16/53 Assembly Time 12 Midnight 10/17/53	12 Midnight 10/17/53 6 AM 10/24/53	
12. Feed Roll Drives - Install Mill Feed Roll Drives, See Section ___ Of Major Material And Equipment Schedule.		R.R.Eng.& Cars Mill Crane	All Field Force Crafts	8 AM 10/22/53	4 PM 10/23/53	
13. Spindles And Carriers - Install Spindle Carriers, Pivot And Spindles. See Section ___ Of Major Material And Equipment Schedules.		R.R.Eng.& Cars Mill Crane	F.F.Riggers, Machinists	8 AM 10/20/53	6 AM 10/22/53	
14. Roll Change Buggy - Install Roll Change Buggy Base. See Section ___ Of Major Material And Equipment Schedules.		R.R.Eng.& Cars Mill Crane	F.F.Riggers, Machinists	Setting Time 12 Midnight 10/20/53 Assembly Time 12 Midnight 10/22/53	12 Midnight 10/22/53 6 AM 10/24/53	

Figure 11 — Forms were completely preassembled at a location ½ mile from the job site.

the various craft foremen, the engineers and the turns that they were to work. These people were lined up well in advance on the turn that they were to work, the people that they were to work with and what was to be expected of them throughout the entire job. The various charts were given to each of these supervisors so that they could refer to them frequently.

Figure 9 is a schedule for the dismantling of the old equipment. It gives the sequence in which the equipment was to be removed, the disposition of each unit, as to scrap or salvage, and the equipment to be used in handling. The schedule also shows the crafts involved in the dismantling and the time that the job was to start and be completed. As a result of having only two mill cranes, it was necessary to use some caterpillar and mobile units.

The installation of the new equipment was also scheduled, Figure 10. This particular sheet shows the equipment installed near the end of the job. It gives the order in which the equipment was installed, the equipment used in handling, the various crafts involved and again the starting and anticipated completion times.

Another chart was made up which gave additional information concerning the new equipment including manufacturers' drawing numbers, the Inland drawing numbers, piece numbers, the number of each required, the name of the unit, the weights of the units and a remark column for the comments of the engineer on the job. This was done to collect all of the comments and ideas that might benefit in future work of this type.

Charts were also used to graphically show the operation, on which thin marks represented the time scheduled and dark heavy marks indicated the actual time expended.

A black line on the right of these charts indicated the deadline date of the job which was planned to be twenty-six days from the start. The new mill actually went into operation three days ahead of time.

The complete preassembled form is shown on Figure 11. The complete mill foundation formwork, preassembled ½ mile from the job site, included cooling air ducts, tunnel forms, reinforcing steel, foundation

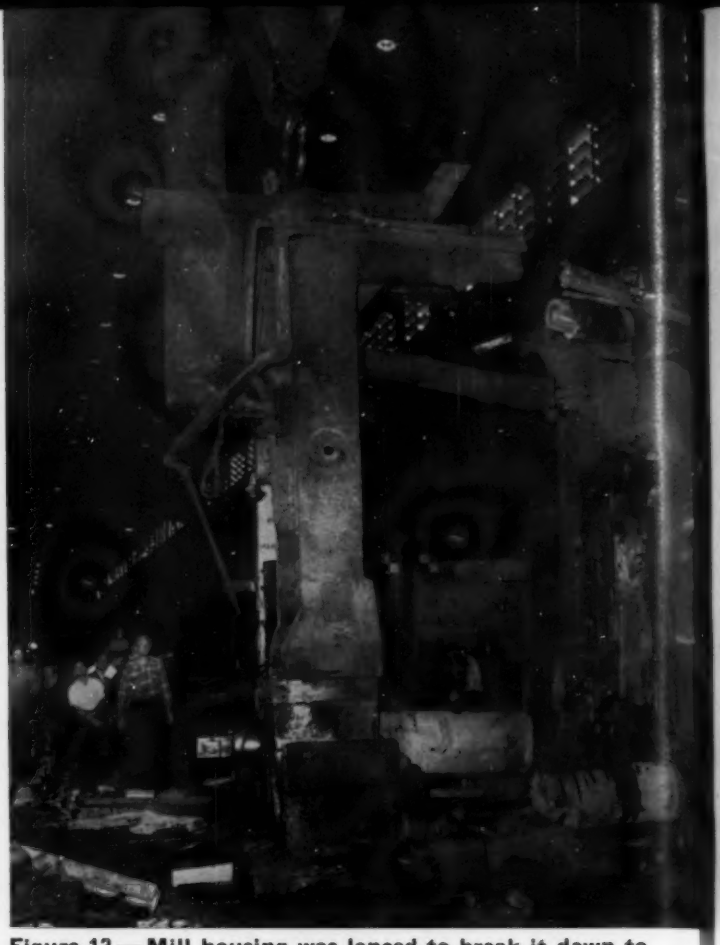


Figure 12 — Mill housing was lanced to break it down to car size pieces.

bolts, conduit, and steel bridging to provide for sectional transportation. During this work, men were assigned on the night turns to provide for fire protection. This form was subsequently cut into ten self-contained units varying in capacity from 25 to 250 cu yd and transported a week in advance to the building in which the construction was to take place.

Figure 12 is a view of the removal of the first mill housing. Note the feed rolls had been lanced, the spreader housings had been broken, and the housing was removed to a point adjacent to the site where it was lanced into car size pieces and the load unblocked was transported to the scrap yard.

Two 2½-yd power shovels were used to excavate the blasted foundations and granular fill. A ramp was

Figure 13 — The first section of the preassembled form is being installed.

cut on a 3 to 1 slope to conserve space, and required the use of a winch for the assistance of trucks and equipment in leaving the excavation. Between the mill columns, the field engineer's office trailer was located on a deck which had been installed on top of the new scale pit settling bases.

Figure 13 gives a close view of the first section of preassembled form being installed. Note the carrying structure incorporated into the form work.

Figure 14 shows the excavation near completion. At this point one power shovel had been removed and the first preassembled form section can be seen in place behind the shovel. The first concrete tower had been erected on the intermediate table foundation bolts after the removal of several rolls. The second section of preassembled forms can be seen on the mill floor in the center background. In the extreme upper right hand corner, one of the temporary platforms used in the completion of wiring and piping can be seen attached to the building columns. Directly beneath this the cooling air duct work can be seen in progress.

Figure 15 is a view of the pinion stand excavation as it appeared from a point over the disassembled main mill drive motor which at this time was being realined to correct uneven settlement experienced in previous years. The motor was realined 1⅛-in. to the elevation of its center point to eliminate the necessity of changing or lengthening its foundation bolts. A point on the realined motor bearing pedestal was subsequently used as a bench mark or control point for the elevations of all new equipment installed. The preassembled form sections completely installed, new scale pit walls and deck carrying the temporary air compressing station can be seen through the previously enlarged spindle doorway in the motor room wall.

Figure 16 shows preassembled form section No. 10 in place complete with foundation bolts, reinforcing, etc. Note that this form section had been prepared several feet short to permit ease of installation. The remaining space between the end of the form section and the old mill approach table foundation was enclosed with forming on the site.

Figure 17 shows the job during a period when the largest concrete pour involving more than 1,000 cu yd was taking place. The two concrete towers with chutes provide a pouring radius of fifty feet and are being used on table beam foundations. The 24-in. pipe chutes from the adjoining building are being used in conjunction with cranes in that location. The two mill cranes can be seen with concrete buckets, the closest one of which was fabricated to provide a capacity of six cu yd equal to the load carried by the largest ready-mix truck. During this period, the highest rate of pour attained was 200 cu yd per hr.

Steel templates were used in conjunction with the preassembled forms. After the pours, it was found that the foundation bolts held their alinement remarkably well and required little or no drifting previous to the installation of new mechanical equipment.

Excellent illumination on the job site, was accomplished by the installation of a complete new lighting system previous to the start of the job.

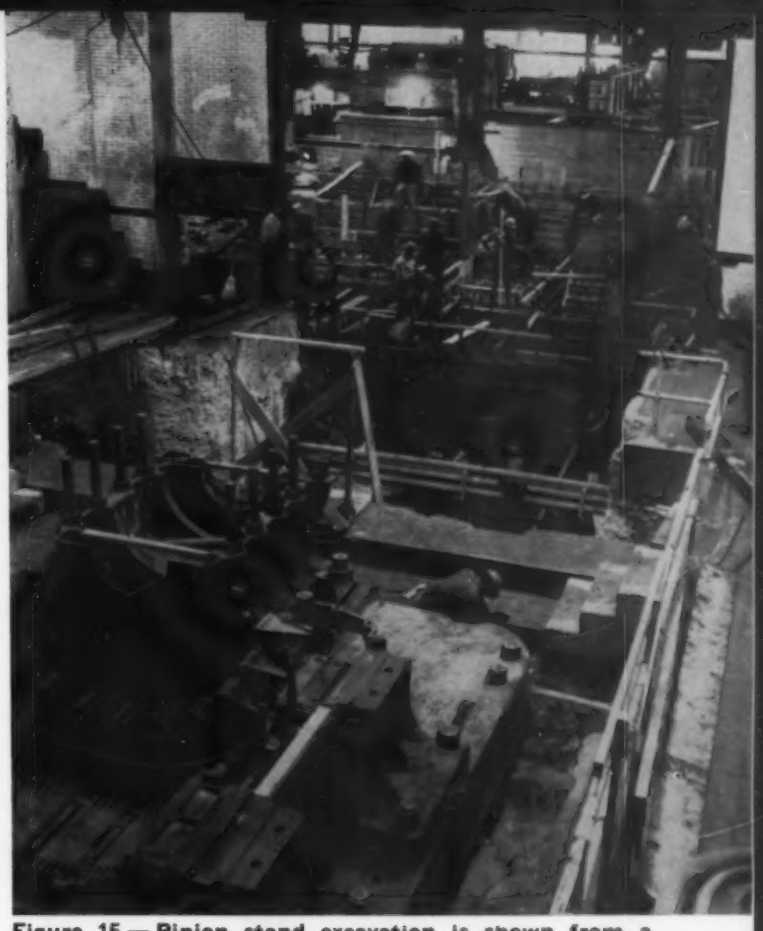


Figure 15 — Pinion stand excavation is shown from a point over the main mill drive motor.

Figure 14 — Excavation is near completion in this view.

Figure 16 — Preassembled form sections were made several feet short to permit ease of installation.

Figure 17 — The largest concrete pour took more than 1000 yd.

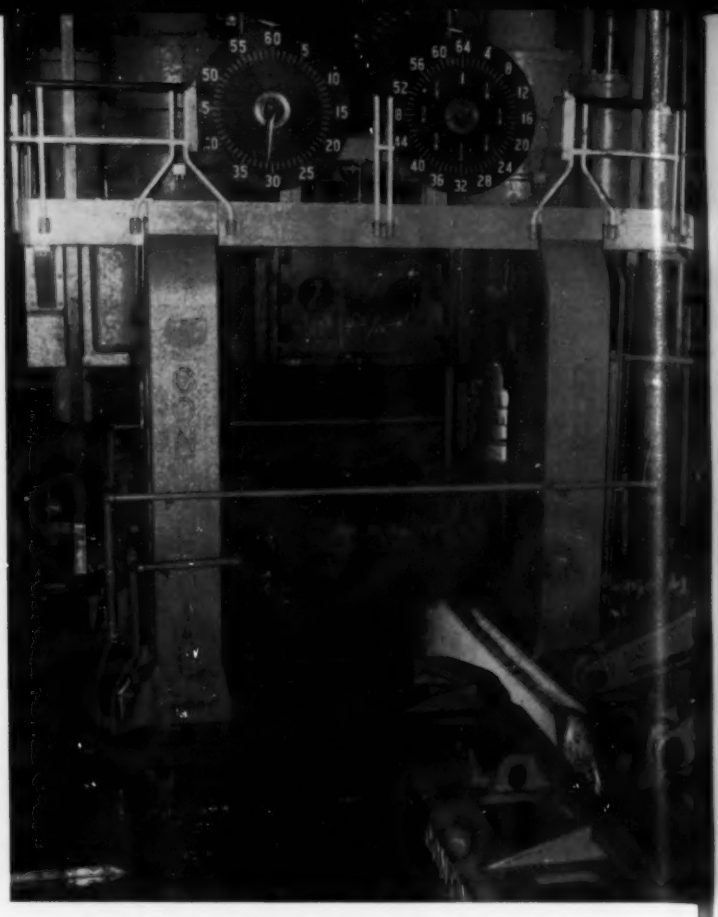


Figure 18 — First ingot to come through the new mill.

Figure 18 shows the first ingot to be rolled in an edging pass. This took place twenty-three days and forty-five minutes after shutting down the original mill equipment.

The mill operating people had been in touch with the construction progress and the installation of the new equipment and were relatively familiar with the installation at the time they were called upon to go into production. Normally this pulpit is occupied by the roller, manipulator and quality control people.

Figure 19 shows the new mill in production on the first day. Previous to starting up the new equipment, the entire area had been cleaned up and all of the new equipment, walls, columns and runway girders had been painted.

This project involved:

1. The removal of 1775 tons of mechanical equipment.
2. The removal of approximately 2400 cu yd or 4800 tons of old foundation concrete.
3. The removal of approximately 2800 cu yd of slag and granular fill.
4. The use of nine carloads of form lumber.
5. The use of 192 tons of reinforcing steel, imbedded rails, structurals and plates.
6. The installation of 3171 cu yd of new foundation concrete.
7. The installation of approximately 2300 tons of new mechanical equipment.
8. The installation of approximately three miles of piping.
9. The installation of approximately 12 miles of conduit and 73 miles of wire and cable.

The total downtime from ingot to ingot was 23 days and 45 minutes. The mill went into operation without any serious difficulties and in a matter of two days was producing steel at a higher rate than the old mill record average.

With the exception of the blasting and supplying of ready-mixed concrete, the entire job was done with Inland personnel.

The benefits derived from the rebuild and additional pits were in line with those anticipated:

1. Mill and maintenance delays were substantially reduced.
2. Maintenance costs were reduced.
3. The mill capacity was increased by 18 per cent.
4. The new scale removal system reduced costs of handling scale.
5. The entire project resulted in a safer, cleaner mill.

The entire second step of the rehabilitation program has subsequently been approved and construction work started.

Figure 19 — Within two days the mill produced more steel than the old mill's record average.

Modern European hot blast Changing Equipment

By HERMAN JANSEN
Vice president of operations
Zimmerman & Jansen
Dueren, Rhineland
Germany

The following paper gives a general survey on modern European hot blast stove changing equipment . . . . features of practice are complete mechanization of reversal, centralization of supervision, high efficiency burners and short reversal times.

▲ THE first hot blast stoves were built in 1828 in Great Britain as tube heat exchangers. Heating was done by a normal coal fire. About the same time, the first hot blast stoves were erected in Germany mounted on the top of the blast furnace using the sensible heat of the blast furnace gas.

The first combustion of blast furnace gas using the latent heat of the blast furnace gas was done in 1832, and utilization of the blast furnace gas made great strides from that time.

With those first hot blast stoves the top temperature reached 570 F and only after Cowper introduced the regenerative heating was it possible to come up to 1100 F.

About 1880 stove design progressed to the integral combustion chamber and from that time there has been no great difference in the principle of design with present stoves.

All the valves mounted at these first stoves were simple hand operated bell-shaped valves corresponding to the technical knowledge of that time.

The loss of gas and blast was relatively high and 1880 when the first turning valves were used marked an important advance. These valves consisted of a removable bend and were mounted at the gas inlet and the waste gas outlet.

Shortly after that, a new type of valve, the so-called Schmidt'sche goggle valve, came on the market and brought a further essential progress so that sometimes one may find them on old existing hot blast stoves.

The use of blast furnace gas to drive the large gas engines and the necessary introduction of gas precipitators allowed more and more the use of slide valves for the hot blast stoves. These valves were operated by hand using racks or spindles.

Fundamental tests on hot blast stoves and combustion pointed to the necessary installation of fans for the combustion air. Using those fans, the efficiency of the hot blast stoves came up to about 65 per cent.

Taking equal times for heating and for the blast period, there was now a possibility of going from the 4 or 5 stoves per blast furnace to the 2-stove-system.

Shortly before the first world war, the uncooled hot blast valves changed in their design to the water-cooled type with plates and sealing rings made of copper.

The time to change a stove with those valves took from 10 to 15 minutes. During the changing time, the normal gas consumption was interrupted so that it was necessary to burn the excess gas and additional time was lost for heating the stoves. Only when compressed air or electricity came into use to operate the different valves in an interlocked sequence was there an opportunity to bring the stoves to higher efficiency.

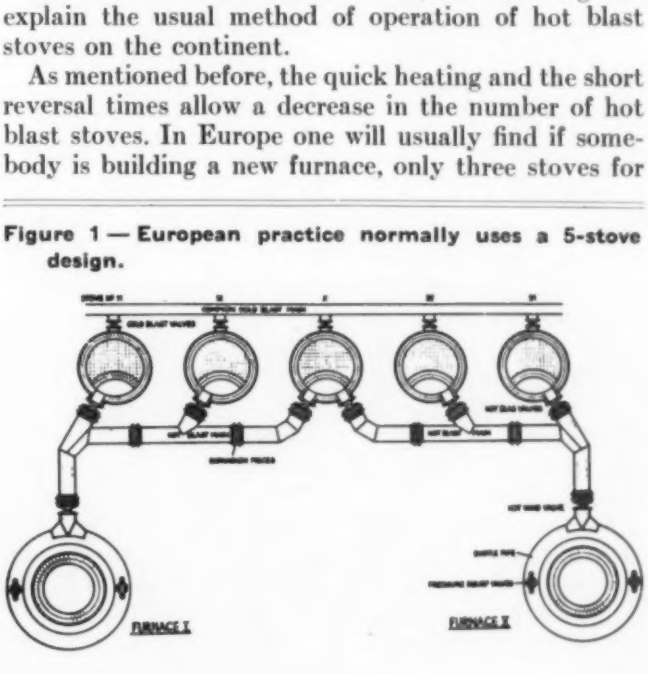
Based on thermal knowledge, the blast furnace builders came to the so-called high efficiency brickwork. The very much increased heating surface allowed a very high efficiency of these hot blast stoves. But it was only possible to use that high efficiency brickwork when gas and air were led under pressure into the stoves. Based on these findings high efficiency burners were designed.

The efficiency of modern European hot blast stoves is increased to 90 per cent and the consumption of gas which is very important on the continent, is decreased to about 20 per cent.

After this short historical review, the following will explain the usual method of operation of hot blast stoves on the continent.

As mentioned before, the quick heating and the short reversal times allow a decrease in the number of hot blast stoves. In Europe one will usually find if somebody is building a new furnace, only three stoves for

Figure 1 — European practice normally uses a 5-stove design.



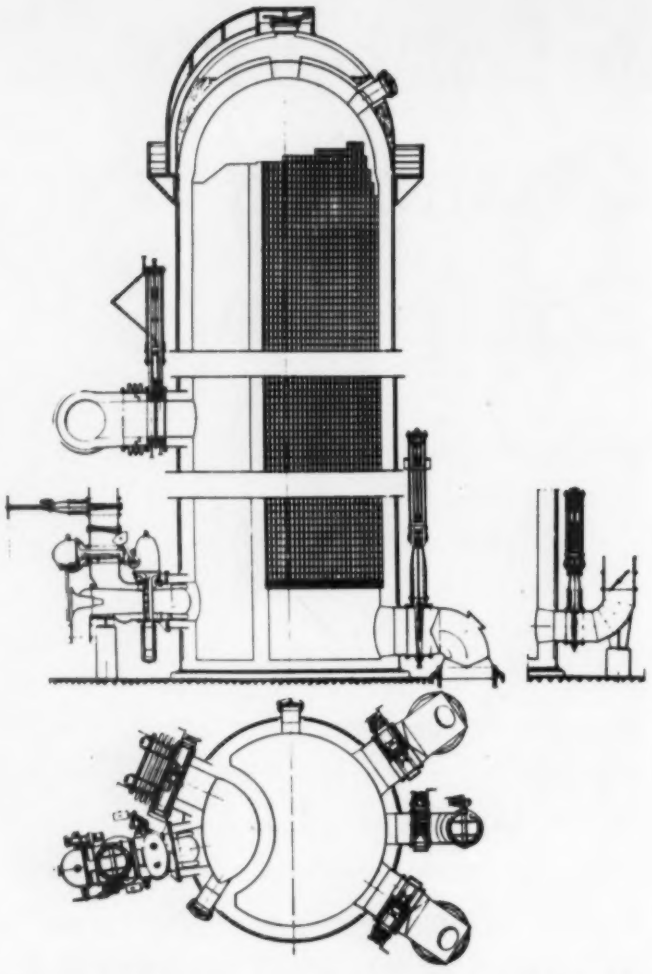


Figure 2 — Schematic shows typical arrangement of valve layout used in Europe.

one furnace. In the 2-stove operation there will be one stove on gas, one stove on blast and the third stove held for reserve.

Sometimes one will find on the continent only five stoves for two furnaces, so that both furnaces have only one stove on reserve, which can be switched in emergency either to No. 1 or to No. 2 blast furnace. That stove is then equipped with two hot blast valves which can be operated either in the automatic control with No. 1 furnace or with the other hot blast valve in automatic control with No. 2 blast furnace. Figure 1 shows a typical 5-stove-design in which the center stove is equipped with 2 hot blast exits.

Working in the 2-stove-system, each burner must burn the necessary gas volume in about one hour to give the required heat to the blast.

The largest burner built up to date has a capacity of 35,000 cfm. Sometimes these volumes are not sufficient for large new blast furnaces which need up to 40,000 cfm and more.

In this particular case it is necessary to go over to the 3-stove-system, that means two stoves on gas and one stove on blast. Then one will get a heating time of two hours.

Before starting with further information about practical hot blast stove operation in Europe, the burners and valves normally used will be described. On Figure 2 one will see an arrangement of these valves in cross section and layout.

The next important difference one sees on this figure is that it is European-practice to mount the burner, not on the platform, but on the floor. This is only possible when the valves are automatically operated in interlocked sequence and the stove tender does not have to go to particular valves when he changes the stove. He will make the reverse entirely from the panel in the control room.

As seen on Figure 3, the burner has separate conduction of gas and air. Both media come together for the first time at the burner head which means inside the combustion chamber.

By means of the vanes mounted at the burner head, one medium is twisted clockwise and one in opposite direction, that means both are intensively mixed before they are ignited.

Figure 4 shows three burner heads for burners of different capacities. On this picture one easily sees the different vanes.

In addition to the mixing given by the burner head, the media is further mixed when it strikes against the wall of the combustion chamber. As the result of this mixing, the flame in the combustion chamber will be very short so that delayed combustion is impossible

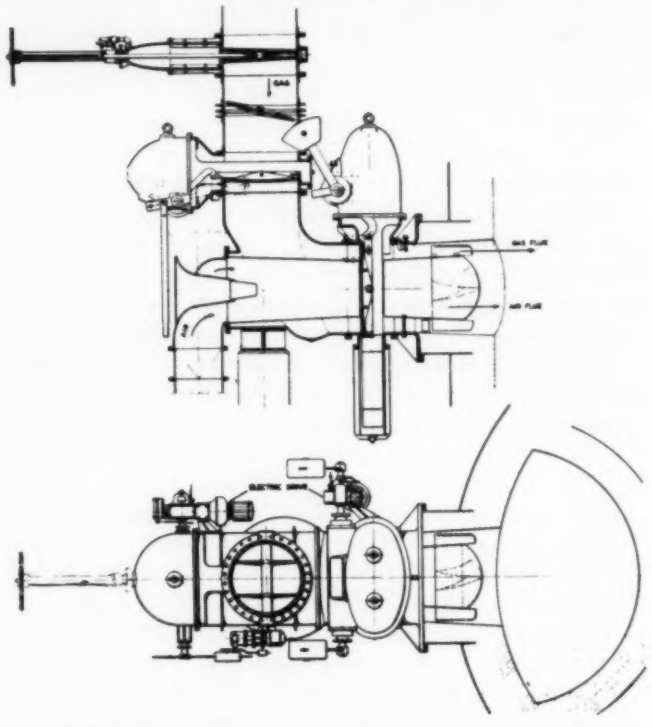
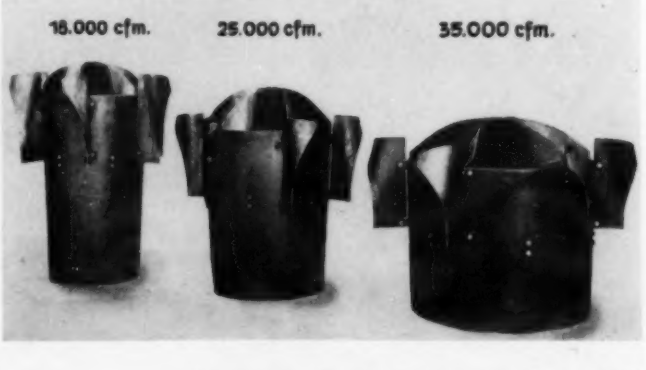


Figure 3 — Burner has separate conductors of gas and air.

Figure 4 — View shows heads for three different sizes of burners.



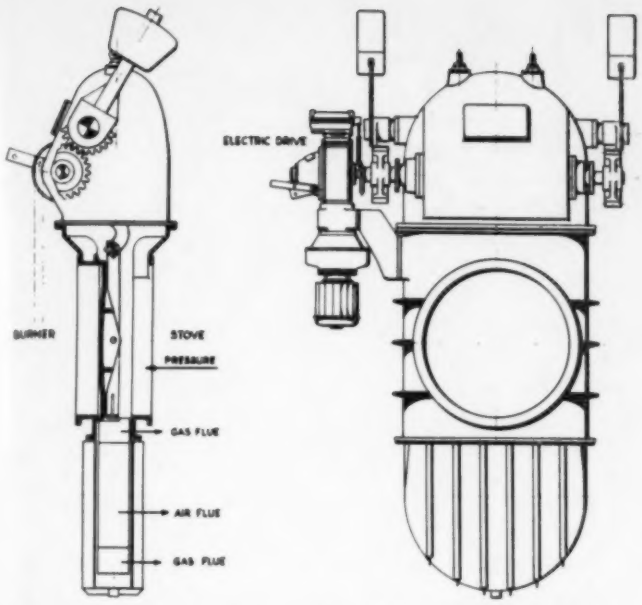


Figure 5 — Burner shut-off valve is just behind the stove connection piece.

in the dome or in the upper part of the checkers. There is no reason to be afraid that the wall of the combustion chamber will be destroyed by the heat of the flame, because gas and combustion air both have low temperatures and they hold the combustion chamber wall far below the permitted temperature of refractories. Even at the time of the highest temperature at the end of the gas period, the bricks will get only dark red.

Just behind the stove connection piece is the burner shut-off valve which is particularly shown on Figure 5. This valve separates the stove from the gas and combustion air ducts. To get continuous separate conduction of gas and air, to avoid early ignition in the burner, two concentric following rings hanging below the valve plate are lifted when the valves open, thus making a continuous flue for gas and air.

As an additional part of the burner is another valve of the same design which cuts the gas flow.

Figure 6 shows the both valves of a burner. One sees the burner shut-off valve, which is shown in the open position, and the two before mentioned following rings.

Both valves have an electric drive and an emergency hand drive and work in the interlocked sequence of the other valves of the stoves.

One important point, is that the burner is open in the back as shown in Figure 3. This enables looking through the center of the burner into the combustion chamber.

If any repair work is necessary in the burner or in the combustion chamber, there is an additional double plate valve in the gas main as shown on Figure 7. This valve is hand-operated and does not work in the sequence. As it closes, a mechanical port opens to the atmosphere venting the space between the two plates. Any gas which passes through the first plate sealing will always go the easier way to the atmosphere than try to come through the second plate sealing.

The necessary combustion air for the burner normally will be delivered by a fan as is also the custom in the United States.

Referring back to Figure 2, which shows the arrangement of the waste gas exits, normally one will find two chimney valves for a stove with higher capacity if the space allows such an arrangement.

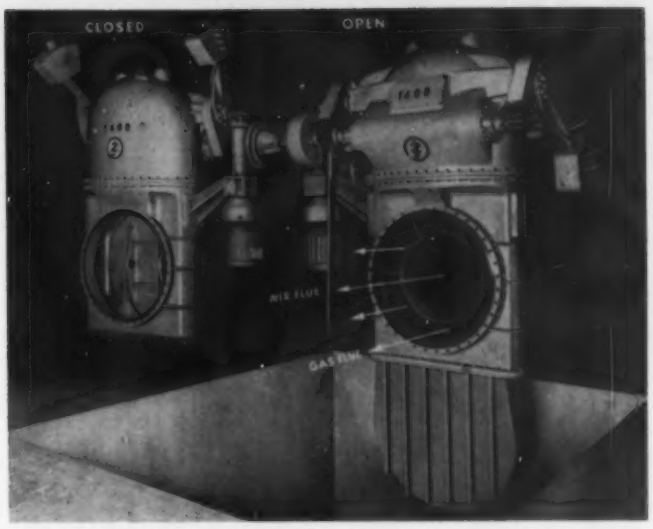
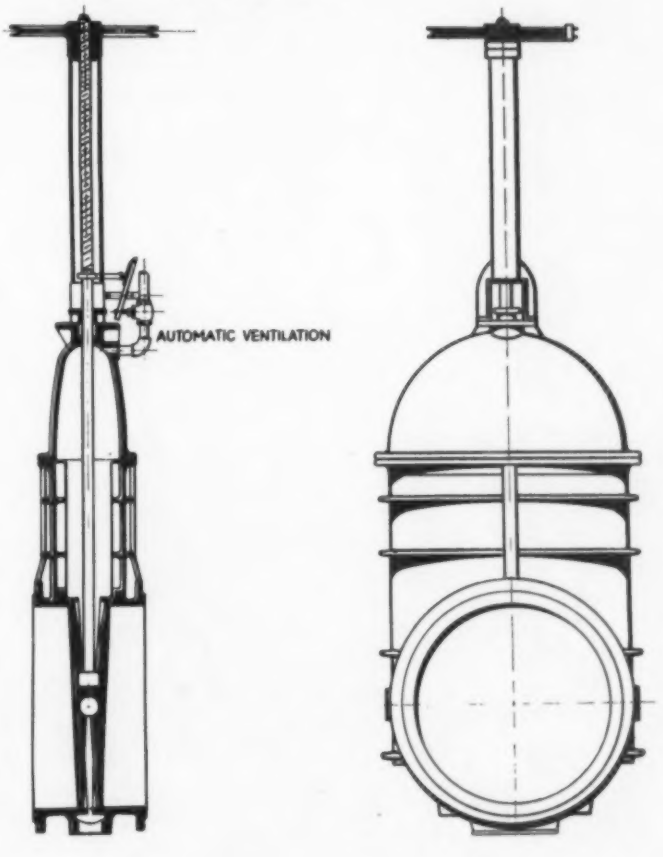


Figure 6 — Burner shut-off valve is shown in the open position.

Figure 9 shows a chimney valve and its cross section. The valve itself is a gate type valve, but sealing only on one side. The plate is pressed against the sealing face by two wedges on both sides of the valve. In addition the cold blast pressure presses the plate strongly against the sealing face. In the main plate there is a small relieving plate which opens first when the stove is changed from blast to gas so that the stove can be relieved into the chimney flue. Only when the pressure is equalized will the main plate open.

Figure 7 — An additional double plate valve helps when maintenance is necessary.



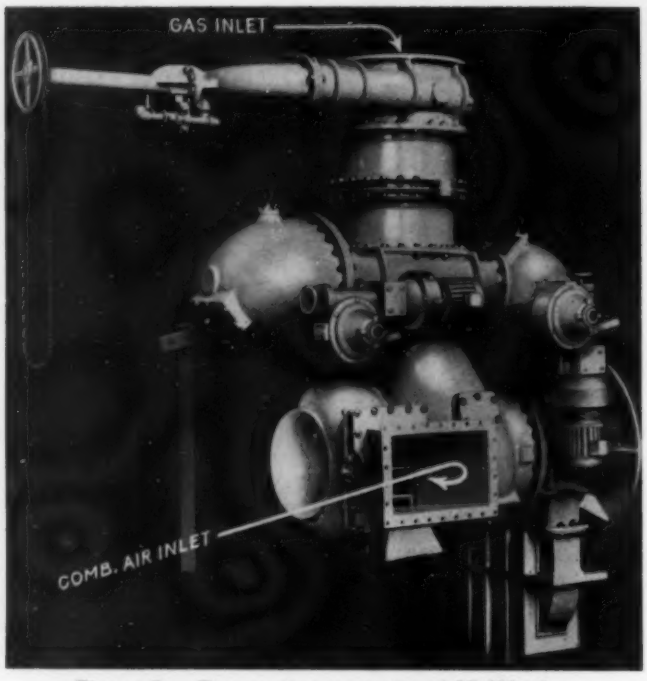


Figure 8 — Burner has capacity of 25,000 cfm.

The operation of the chimney valves is done by electric drives. Each valve has a hand winch as standby for emergency cases.

If a hot blast stove has two waste gas exits, usually only the one which opens first when the stove is changed from blast to gas has this particular relieving plate. The second chimney valve works only when the pressure is equalized.

On Figure 10 is shown a completely fitted chimney valve on the test stand. The waste gas elbow sometimes is made in a square design with guide plates which save 50 per cent of friction.

Figure 11 shows the cold blast inlet with the cold blast valve. In principle it is the same design as the chimney valve with relieving port.

In changing the stove from gas to blast, the pilot valve first opens to fill the stove with cold blast. The cross section of the port is so dimensioned that neither too much time is lost in filling the stove nor too great a pressure drop is experienced in the cold blast line.

Figure 12 shows a group of three hot blast stoves each with two chimney valves and cold blast valve.

The last valve in the sequence of the automatically operated stove changing equipment is the hot blast valve, shown on Figure 13. The construction is quite different than is normally used in the States. The valve has two water cooled sealing rings in copper. The valve plate is also water cooled and made of copper. This valve always will be operated at equalized pressure so that the friction between ring and valve plate is very small. The good sealing effect of that valve is attained by the blast pressure which presses the valve plate strongly against the sealing ring from the side of the hot blast main. The operation mechanism is the same as already described for the chimney and the cold blast valve.

On the top of the burner, the gas butterfly valve for the regulation of the gas volume is equipped with an electric drive so that the operator can control the desired gas volume by push-buttons from the panel.

The combustion air butterfly valve is controlled by the gas:air ratio equipment corresponding to the gas volume.

Figure 9 — Chimney valve is a gate-type valve sealing on one side.

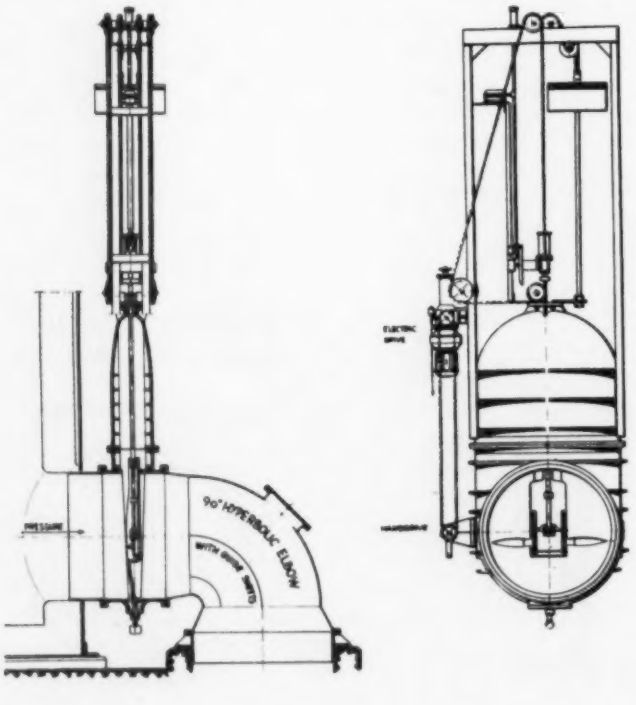
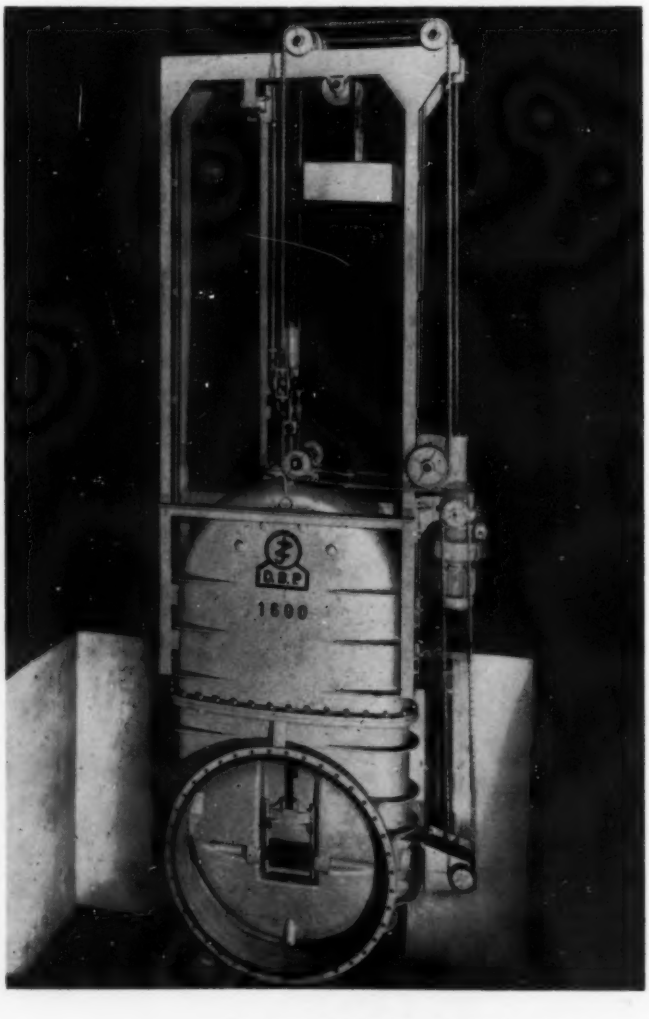


Figure 10 — Chimney valve is shown on test stand.



Sometimes there is instead of an air butterfly valve a fan which gives the necessary combustion air by alteration of the rpm or by particular vane-control.

It is quite common practice on the continent to have two or more blast furnaces blown from a common cold blast main. Then each stove needs an extra cold blast butterfly valve. But more and more the practice is changing to a separate blower for each furnace. Then the cold blast volume is regulated at the blower itself.

As mentioned in the introduction, the first automatic blast furnace controls, still working today were installed between 1925 and 1928. In the meantime, most of the blast furnace plants in continental Europe have changed over to this system and now there are about 620 automatic installations in the world.

Up to the last world war, most of the automatic controls were operated by compressed air, but now the blast furnace people have changed more and more to electrically operated controls. There is in principle no difference with the two different kinds of drive.

This reversing process consists of the completely interlocked sequence of the different valves at one hot blast stove and the operation by only one control selecting switch.

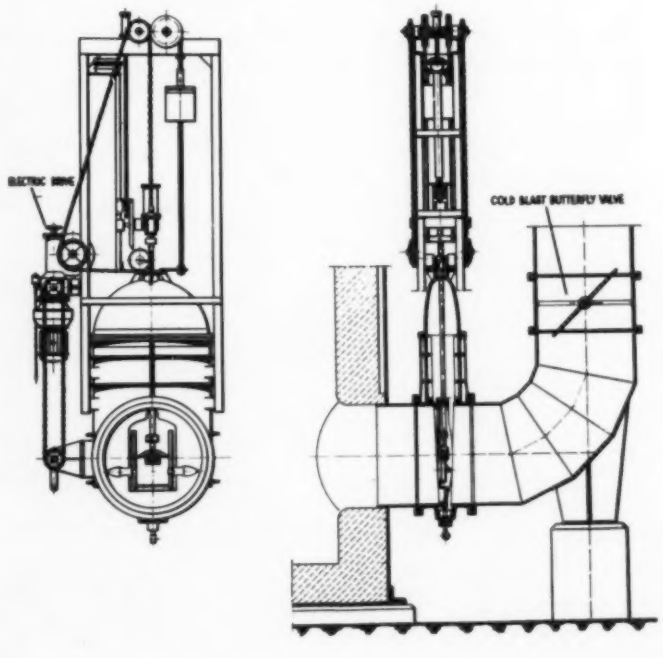
The following stove positions with that switch are possible:

1. "On gas."
2. "On blast."
3. "From gas to stove off."
4. "From blast to stove off."

The impulse transmission from one valve to the next one is designed so that the following valve will start moving only when the valve before has really reached the end position. For example if a stove has to be changed from gas to blast the valves will be operated in the following interlocked sequence:

1. Gas shut-off valve closes.
2. Burner shut-off valve closes.
3. Chimney valves close.

Figure 11 — Cold blast inlet is the same design as the chimney valve with a relieving port.



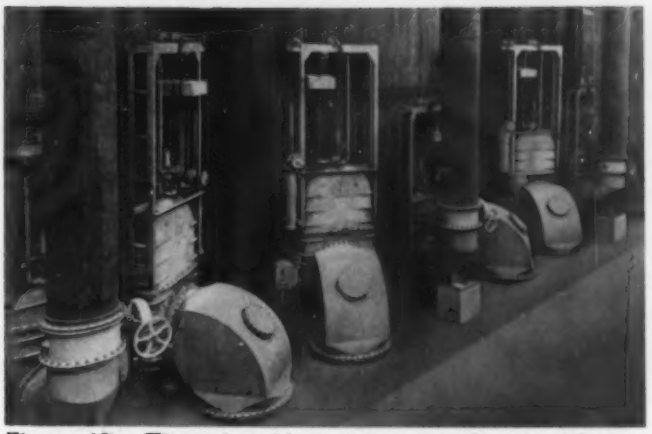


Figure 12 — Three hot blast stoves are shown with two chimney valves and cold blast valve.

4. Cold blast valve opens.
5. Hot blast valve opens.

A wrong control is completely impossible. Should it not be possible to operate a valve by any fault, or should a valve not be able to reach its end position immediately, the automatic control is interrupted and the following valve will not work. A later, more detailed described remote signal equipment shows which of the valves did not work satisfactorily.

If anybody during the shut down of the blast furnace sets manually one or more valves in the wrong position, all the valves will come into the right sequence alone when the stove tender operates them again from the control selecting switch.

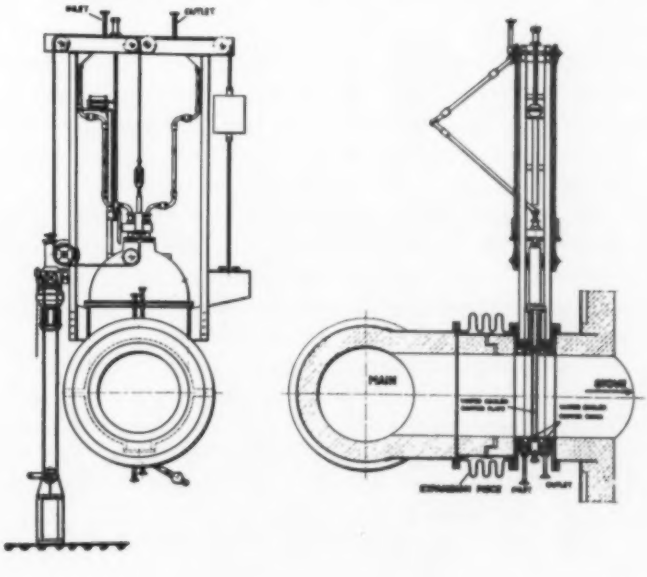
With respect to the time it takes for a change-over, naturally the time depends on the diameter of the different valves and also on the cold blast pressure. Normal experience in Europe is that a time between 45 and 75 seconds is necessary.

On the continent usually, the stove tender does not see very much of the whole reversing equipment. He only has his instruments and for one stove one control selecting switch with the four different positions.

The impulse transmission is effected by special limit switches at the different valves.

At the chimney and cold blast valve, the working

Figure 13 — Last valve in the automatic sequence is the hot blast valve.



circuit opening the small valve plates will be interrupted long enough to equalize the pressure with the mains. Then the big plates will be opened by a newly closed circuit. The control system is so interlocked that each valve must reach its end position. That means that if there is a shutdown on the furnace and backdrafting through the stoves is wanted, the valves would be in the wrong position. But there is no difficulty in combining backdrafting with that system. It means that an additional switch has to be mounted on the panel.

If that switch would be turned to backdrafting, the chimney valves, the burner shut-off valve and the gas valve would be opened and the cold blast valve would still remain closed. The hot blast valve would be also opened to draft the gases coming from the blast furnace into the chimney flue. The electrically operated mixed blast valve would still remain closed to exclude any gas: air-mixture with its danger of an explosion.

Through the burner is passing a small volume of gas with very much excess air which gives an ignition flame to burn the backdrafting gases from the blast furnace. All the valves would go automatically in that backdraft position with the same interlocked system as it is done with the normal stove change.

In Europe blast furnace people do not like to work on this backdrafting system. They have instead of this quite another and less dangerous method of burning the drafted gases from the furnace.

Between No. 1 stove and the furnace an additional hot blast valve is fitted which is slightly different from those hot blast valves which are at the stoves, and to make a difference between this valve it is proposed to call it "hot wind valve." Design and construction of that hot wind valve are much stronger than for the hot blast valve. This valve can be operated against a pressure up to 15 psi, whereas the hot blast valves are only operated in equalized pressure. This hot wind valve has, like the chimney valve, wedges on both sides which press the plate against the sealing face because there is no pressure in the main which helps to press the plate against the sealing faces in the closed position.

In addition to this hot wind valve between No. 1 stove and the furnace, there are on the bustle main one or two pressure relief valves, depending on the size of the furnace.

This pressure relief valve has electrically operated drives for the catch and the cover or pneumatic cylinders for both. The drives are designed strong enough to close the cover against a pressure of between 15 and 45 psi.

Working of this equipment for the prevention of explosions is very simple. If the cold blast pressure in the cold blast main drops below a preset figure adjusted at a contact manometer, then a circuit is closed and the hot wind valve will close automatically separating the stoves from the furnace.

Then a further contact closes another circuit to open the pressure relief valve. If the pressure in the cold blast main rises again over that preset figure, first the pressure relief valve will close automatically and after that the hot wind valve will open.

If there is a shutdown at the furnace, any gases passing through the tuyeres will escape straight through the pressure relief valves and if necessary conducted to the top of the furnace where they will be burnt.

It is also possible to operate this pressure relief valve and the hot wind valve separately. One has the opportunity to slip the furnace when it hangs. The pressure is quickly released and normal pressure is restored quickly when working with these special valves.

There are some other additional controls and safety-devices which are connected with this automatic stove changing control.

If for any reason the necessary combustion air supply is interrupted, there is the danger that unburnt gas would enter the stove without sufficient combustion air. To prevent that, a contact manometer in the combustion air pipe closes a circuit which gives an impulse to close the gas butterfly valve at the same moment when the pressure in the combustion air pipe drops below a preset figure. Any gas passing between housing and plate of the butterfly valve gets sufficient combustion air by the open construction of the burner.

To be certain in cases when the whole current in the works fails and that the gas butterfly works as described above, they often have on the continent the gas butterfly valve equipped with d-c motor which is then operated automatically from emergency batteries.

Another safety device which is combined with these burners is an electric ignition equipment. An electric circuit is automatically closed when changing from blast to gas at the moment when the burner shutoff valve starts opening.

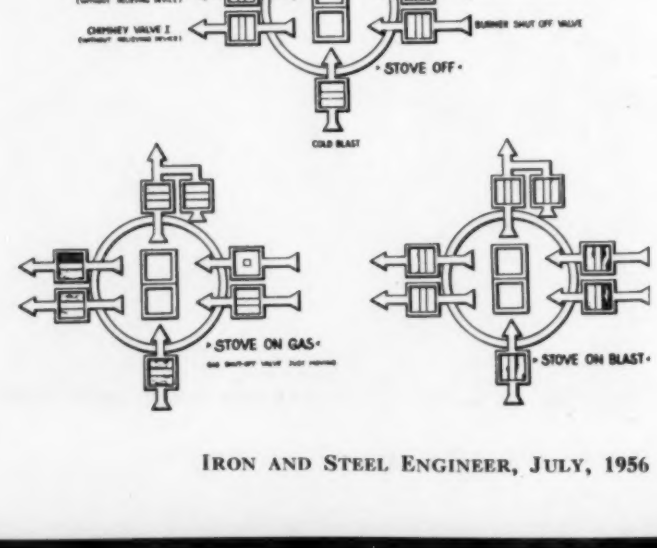
By this circuit, an electric wire glows and a time relay shuts it off after about 60 seconds. If the stove is working under normal conditions, the combustion chamber is hot enough to ignite the mixture, then the glow wire can be shut off.

A remote signal shows the stove tender on the panel if the gas has ignited.

All aforesaid valves are remotely controlled from a central point and one can find on the continent up to four furnaces all controlled by one stove tender from a central control room.

To show the stove tender what the positions of his

Figure 14 — Stove symbols located in squares of the schematic indicate position of stoves.



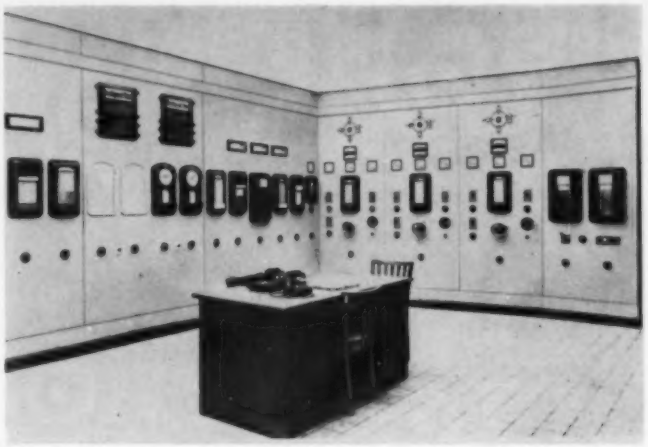


Figure 15 — Furnace panel is so set up as to aid in centralized control.

different stoves and valves are, there is on each stove panel a special symbol. In such a symbol there are position indicators for the different valves.

Light stripes show if the valve is opened or closed. If only the central light in such a symbol is in action, that means that this valve is just moving.

Two red signal lights in the center show that the fan motor is running and that the ignition equipment is working.

These stove symbols show the man with one glance the position of the stove. If all the stripes are in vertical position then the stove is on blast, if all the stripes are in horizontal position, then the stove is on gas and if they are tangent to the circumference of the symbol then the stove is off. See Figure 14.

The assembly of many stoves for several furnaces in a central control room offers an opportunity for the operator to make a mistake. However, even if the operator should turn the wrong switch nothing happens.

The reversal equipment of the stoves is so interlocked, one against the other, that it is impossible to take a stove from blast to gas before another one has not gone from gas to blast.

Simultaneously with centralization of the reversal equipment, new supervising and regulating equipments have been designed.

Figure 15 shows a furnace panel and the three hot blast stove panels. The hot blast stove panel has the following instruments: on the top are the three stove symbols; just underneath each are the gas and air indicators; on the left side, the indicator shows the position of the gas butterfly and on the right, the position of the combustion air butterfly valve.

Because the two furnaces have a common cold blast main, each stove has its own cold blast butterfly valve. Its position is shown on the central indicators. The recorders from left to right show the dome temperature, the stack temperature and the hot blast temperature. The left push button operates the gas butterfly valve and underneath this is the main switch for that valve; on the right side there is the same installation for the cold blast butterfly valve. In the center there is the control selecting switch for the four positions of the stove. On the left beside this switch, are push buttons and the main switch for the combustion air fan. On the right is the gas-air ratio controller.

To get good combustion it is essential that in spite of fluctuating gas volume there must be always the right gas-air ratio.

An electrically or oil-driven control is normally used. The gas volume is fixed by controlling the gas butterfly valve, depending on the necessary calories to heat the checkers. The combustion regulator controls then automatically either the electrically driven or oil driven controller.

Because the dome temperature of a stove is limited to a preset temperature, very often the dome temperature regulators are combined with the gas-air ratio control. If the preset dome temperature is reached then this regulator overrides the gas-air ratio control and normally allows up to 50 per cent excess air, so that the dome temperature will never go over that figure. When the temperature is going up, more and more excess air is added, thus pushing the heat in the lower part of the checkers. Therefore during the heating period the same volume of gas is used and only when the stack temperature goes over a preset figure, an overriding regulator closes the gas butterfly valve or operates a horn or a light signal and the stove can be taken off.

In the United States, the mixed blast normally enters the hot blast main through each hot blast valve chamber. Thus each hot blast valve has its own mixed blast valve which has to be opened and closed when changing the stove. Working with automatic control, these valves have to operate also in the interlocked sequence. In continental Europe, there is normally one connection of the mixer main into the hot blast main. The temperature is regulated by a hot blast temperature regulator which works on a butterfly valve in the mixer main.

SUMMARY

1. Equipment features a complete mechanization of the reversal with the possibility of taking several stoves for one or more blast furnaces together in one control room, thus making service and supervision very easy.
2. This centralization of supervision is normally used in continental Europe and in one case, four furnaces with 12 stoves are centralized and controlled from one control room.
3. Mechanization of the reversal gives the greatest dependability, because all the valves are working in full interlocked sequence and the time which is taken for these reversals is very short. In addition, the periods of excess gas during a change of the stoves are reduced to a minimum.
4. The high efficiency burners connected with these short reversal times and the simple operation allow one to change the stoves as often as necessary, which means that the checkers will not be cooled so much and the disadvantages of thermal shocks in the stoves are avoided. The difference between the maximum dome temperature and the minimum dome temperature normally lies between 180 and 360 F.
5. Short reversals and low temperature drops in the checkers permit the stoves to operate on a very high temperature level. By using just the cream of the heat, the blast temperature is normally much higher. In some blast furnace plants in continental Europe, blast temperatures reach up to 1750 F.

American Iron and Steel Institute

64th General Meeting

. . . . to review problems of iron and steel production, leading operators of the steel industry met in New York City on May 23 and 24, 1956 at the general meeting of the American Iron and Steel Institute . . . . among the meetings were two technical sessions, one on finishing operations and one on blast furnace and raw materials . . . . some of the papers of particular interest are abstracted here . . . .

"PRINCIPLES OF A METALLURGICALLY AND PHYSICALLY BALANCED HOT STRIP MILL"

By M. ALEXANDER LEISHMAN
Works Manager
Hamilton Works
The Steel Company of Canada, Ltd.
Hamilton, Ontario, Canada

▲ AN investigation has been conducted to determine the principles governing the metallurgical and physical balancing of a hot strip mill. Factors relating to different sections of the mill have been discussed and relationships derived which will allow the integration of the components of the rolling system. These relationships enable optimum coil lengths and weights to be calculated for metallurgically balanced operations. A nomogram has been developed for the rapid estimation of these optimum coil lengths and weights for any combination of rolling conditions. The suggested method may be used for calculations of optimum ingot sizes, the number of slab reheating furnaces required, the adjustment of mechanical and electrical equipment and, generally for the production and plant expansion planning on a long-term basis.

In an integrated steel plant, conditions which are good for the highest production rate and quality in one mill might be, and sometimes are, harmful to high output rates and quality in another mill. For instance, very heavy and long hot band coils, a condition desirable in the cold reduction mill, present difficulties in the hot strip mill and in the open hearth. Even within the hot strip mill such contradictions will arise. Thin and light slabs are easy to heat and desirable finishing head and tail temperatures off the continuous mill are easily obtained, but at the expense of high production rates both in the hot and cold mills. Also, good rolling practice on the roughing mill or train, which will give proper metallurgical entry temperature to the finishing stands, might curtail or exceed the physical possibilities of the finishing unit and the slab heating furnaces. A hot strip mill design which will balance metallurgical and physical requirements will give the best production rates compatible with steel quality. This design, if established, should not only allow the steel industry to build better hot strip mills but make more efficient those it now owns.

In 1954, an extensive study of different components of our hot strip mill was started. The intention was to develop the capacity and metallurgical limitations of different units in the rolling sequence. From this it was hoped to derive the major factors which controlled the operations of individual units. Then, when these were reviewed simultaneously, relationships would develop which would show the way to ideal coil weights and optimum production with proper quality control. During the investigation, a substantial increase in tons per hour developed.

Briefly, the main equipment in the Steel Company of Canada's hot strip mill is as follows:

Slab heating furnaces — The three slab reheating furnaces are of the zone-controlled, triple fired, end charged, end discharged type. They have an effective heating length of approximately 80 ft and a width inside the brickwork of 20 ft. Heating of the slabs in the heating zone is carried out by eight burners above the steel and six burners below the steel. The soaking zone is heated by eight burners

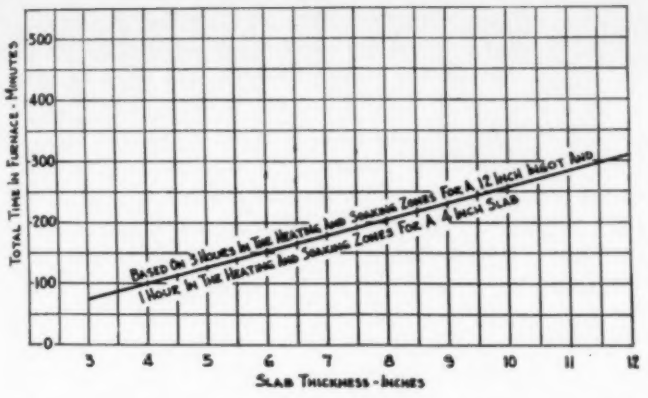


Figure 1 — Chart gives total furnace time required for slabs of varying thicknesses.

spaced across the discharge end of the furnace. All burners are of the combination type for burning gas and oil.

110-in. roughing mill—In the 110-in. roughing mill, the 28-in. diam work rolls are driven by a 5000-hp, 700-volt reversing motor which has an actual speed range of 16 to 100 rpm. The roller has at his disposal a selection of six speeds in each direction.

56-in. Continuous hot strip mill—The mill consists of six 4-high stands each containing two 22½-in. diam work rolls and two 45-in. diam backup rolls. Power to drive the first four stands is transmitted through speed reducers to the work rolls. Motors from No. 5 and No. 6 are directly connected to the work rolls.

The entry temperature of a strip bar into the finishing train of a continuous hot strip mill is influenced by many factors such as temperature of furnace soaking zone, time of slab in soaking zone, transfer time of slab from furnace to the roughing stand, time of rolling in roughing stand or stands, water on the rolls, process steam, thickness of the bar after roughing, transfer time of the bar from the rougher to the first stand of the finishing train, time required to crop the front end of the bar. These will cause bar entry temperature to vary if one or more of these factors vary. In a normally operating strip mill, some of these factors vary so little that they can be considered constants.

In all cases the slabs were kept a sufficiently long time in the furnace, so that their overall plasticity, as measured by the load on the mill motor, was similar to normal operating conditions. This minimum furnace time, established experimentally and indicated in Figure 1, was maintained throughout the investigation. Therefore, the factor "time of slab in soaking zone" was such that its influence on bar entry temperature to the finishing train was constant.

The transfer time of slabs from furnace to rougher (30 seconds ±5 seconds in our case) is consistent, being disturbed only by mill abnormalities.

Cooling water and process steam on the rougher may vary, but not for a given practice, and thus their effect on temperature should be constant per unit of time.

The thickness of the bar after roughing will influence temperature, as radiation of heat per unit volume of steel varies proportionally to the surface area of the unit volume. In our mill, the range of thickness of the majority of strip products is 0.047 to 0.134 in. and requires a strip bar thickness which is approximately 0.75 in. By observation and mathematical treatment, it was found that a range of bar thickness from 0.70 to 0.90 in. had a very small influence on the finishing train temperature. Thus, the strip bar thicknesses exerted a constant influence on temperature.

The bar transfer time from the rougher to the finisher and the front end cropping time were practically constant, being disturbed only by physical delays. Thus a constant influence on temperature was assured.

It was felt that, for a normally operating mill, the finishing train entry temperature could be reliably predicted by the rolling time on the rougher and the temperature in the soaking zone of the furnace.

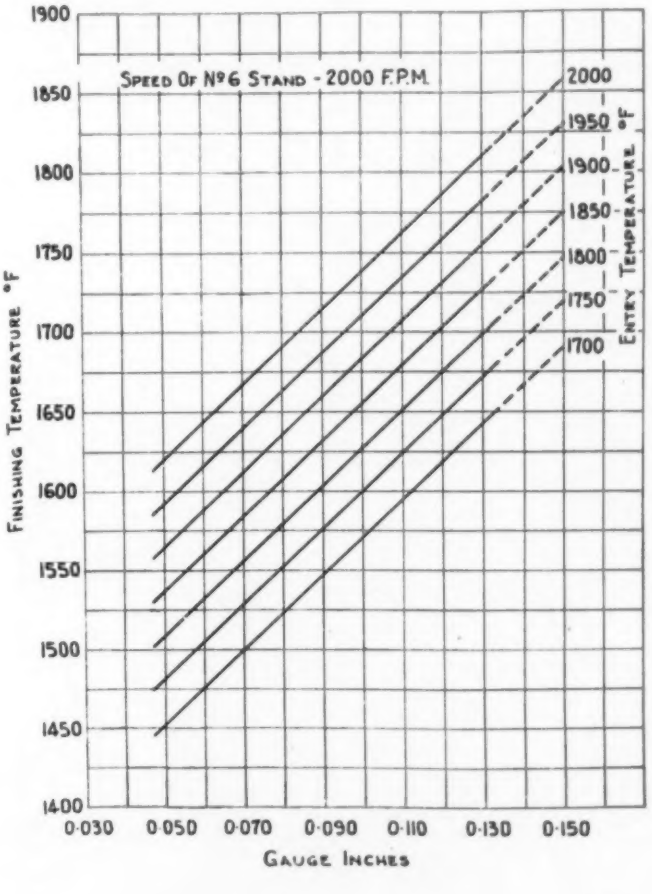
The temperature of the slabs was measured by a radiamatic pyrometer, sighted on the upper surface of the slabs and situated in the roof of the soaking zone.

The rolling time was taken as the time from start of rolling to finish of rolling in the roughing stand.

The entry temperature was measured by an optimatic pyrometer situated just ahead of the finishing train, and was the temperature of the unscaled head of the bar.

Different slab thicknesses, 3½ to 12 in., involving rolling times from 40 to 125 seconds to get down to our strip bar thicknesses, were rolled and the results studied. A sample of over 900 measurements was collected and treated mathematically on the basis of a multiple correlation. The relationship obtained was:

Figure 2 — Finishing temperatures are given for various gages and entry temperatures.



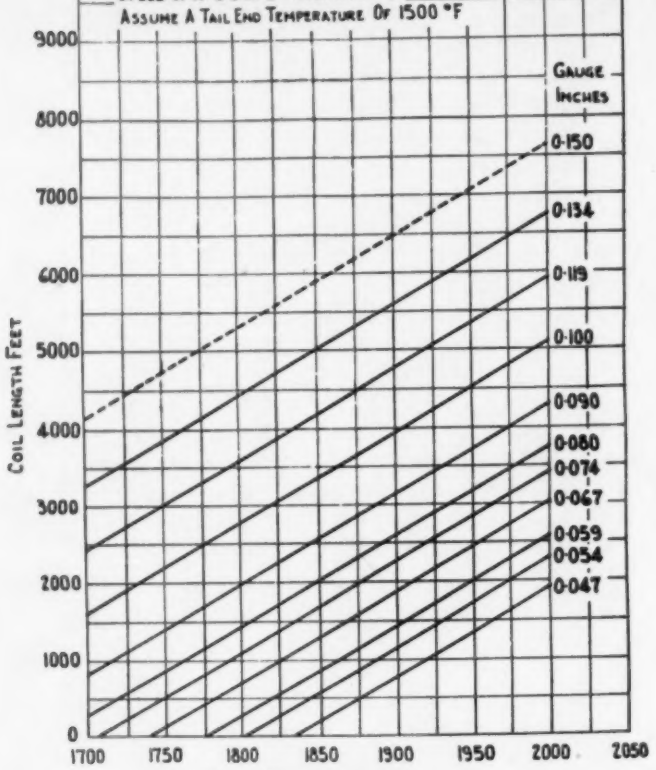
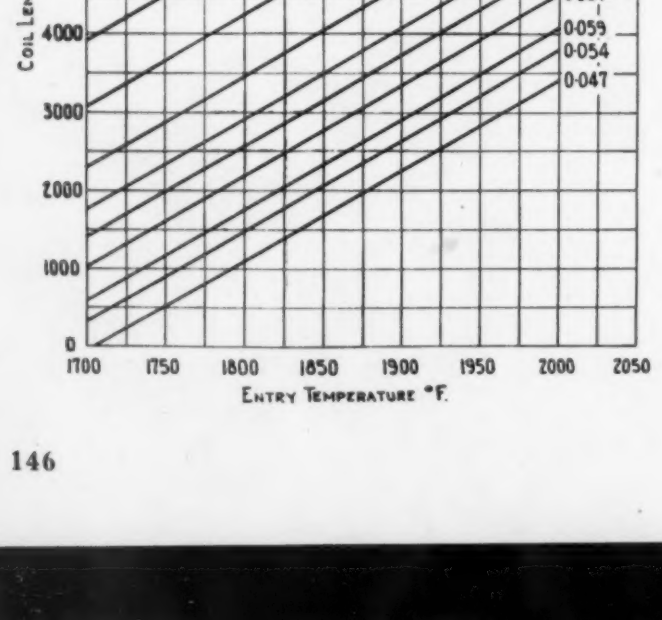


Figure 3 — Coil length (No. 6 stand rolling times) is given for various entry temperatures and gages at No. 6 stand speed of 1500 fpm.

Figure 4 — Coil length (No. 6 stand rolling times) is given for various entry temperatures and gages at No. 6 stand speed of 2000 fpm.



$$Y = 1687.63 + 0.13\,X_1 - 2.42\,X_2 \quad (1)$$

where Y = Finishing train entry temperature, F
X_1 = Temperatures of furnace soaking zone F
X_2 = Rolling time in rougher, sec

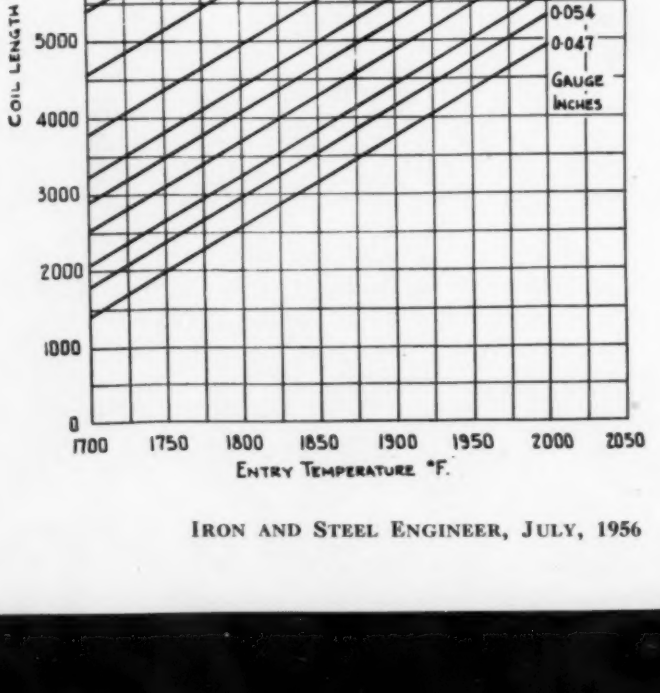
A similar method of approach was used to develop a relationship to predict the strip finishing temperature out of the last stand. The finishing temperature is mainly influenced by the entry temperature, the finishing speed and the gage. The speed takes into account the time of rolling. The width of the material, all other conditions being equal, should have no influence on the finishing temperature. The gage actually is in curvilinear relationship with the finishing temperature, but a linear relationship was assumed for the gages involved, (0.047 to 0.134 in.), with very little loss in accuracy. The following relationship expresses the influence of the entry temperature, the finishing speed, and the gage on the finishing temperature:

$$Y = 135.12 + 0.558X_1 + 0.125X_2 + 2388.56\,X_3 \quad (2)$$

where Y = Finishing temperature, F
X_1 = Entry temperature, F
X_2 = Finishing speed, fpm
X_3 = Gage, in.

In an attempt to determine the temperature difference between the head and tail end of a coil, a multiple correlation was run relating the following variables to the temperature difference, Δ t: ordered gage, finishing

Figure 5 — Coil length (No. 6 stand rolling times) is given for various entry temperatures and gages at No. 6 stand speed of 2500 fpm.



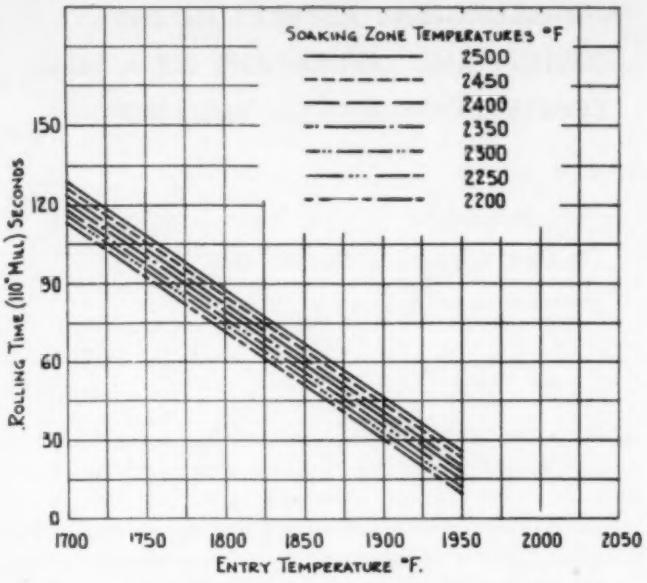


Figure 6 — Rolling times (110-in. mill) are given for various entry temperatures and soaking zone temperatures.

speed, temperature of the head end of the coil and coil length. Using a sample of 1745 tests, the four variables mentioned explained 59 per cent of the variance in Δ t. The final equation for the correlation was:

$$Y = -351.778 - 184.722\,X_1 - 0.012\,X_2 + 0.265\,X_3 + 0.035\,X_4 \quad (3)$$

where Y = Temperature difference, F (Δt+50)
X_1 = Ordered gage, in.
X_2 = Finishing speed, in.
X_3 = Temperature of head end of the coil, F
X_4 = Coil length, ft.

A separate consideration of equations (1), (2) and (3) gives the possibilities and capacities of the two major units in the hot strip mill. The simultaneous consideration of these equations will balance these units and establish optimum coil lengths and weights consistent with good quality.

On the basis of equation (2), the expected finishing temperature for a given gage, finishing speed and entry temperature can be established. Figure 2 shows finishing temperatures for different gages and entry temperatures at a finishing speed of 2000 fpm. Similar graphs can be constructed for any desirable finishing speed.

On the basis of equation (3), the length of the coil of a certain gage at a given finishing speed can be calculated, provided the head and tail end temperatures of the coil, after the continuous mill, are known.

The coil lengths, indicated on Figures 3, 4 and 5, are the maximum obtainable lengths off the continuous strip mill for different gages, finishing speeds and entry temperatures so that, in all cases, the tail end temperature will be approximately 1500 F. The length of the coil and the finishing speed will, at the same time, establish the time required to roll such a coil in the continuous mill.

Equation (1) relates the obtainable entry temperature with the rolling time in the roughing equipment and the furnace temperature. The same relationship, which is independent of finishing gages and speeds, can be presented graphically in modified coordinates as has been done in Figure 6.

The relationships as shown in Figures 3, 4, 5 and 6

Figure 7 — Coil length is given for various entry temperatures and gages.

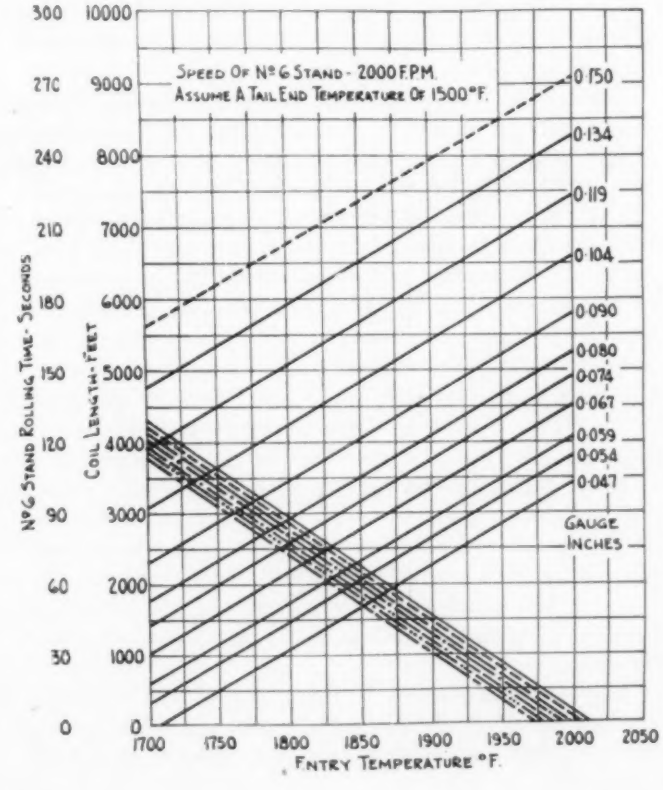
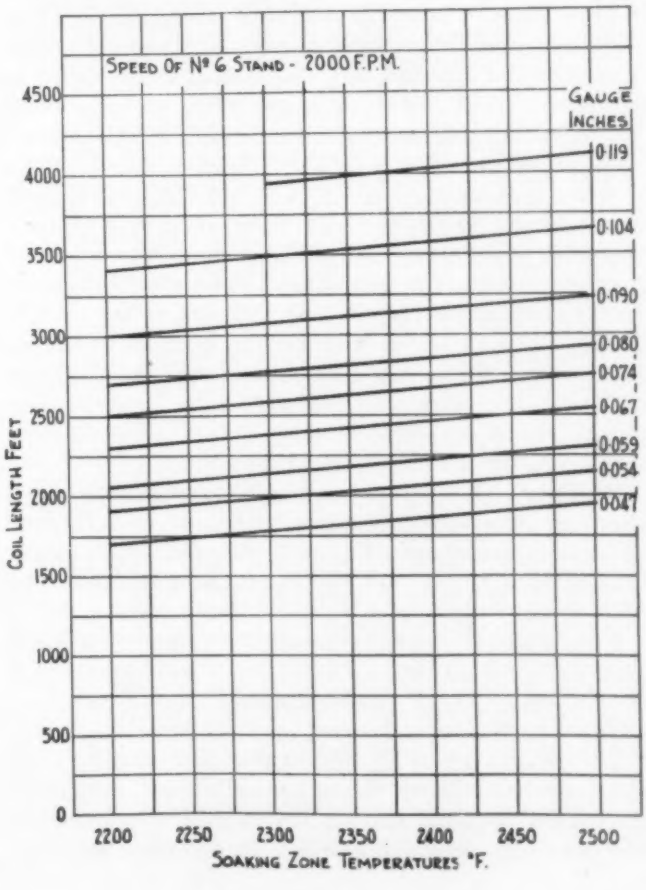


Figure 8 — Coil lengths are given for various gages and soaking zone requirements.



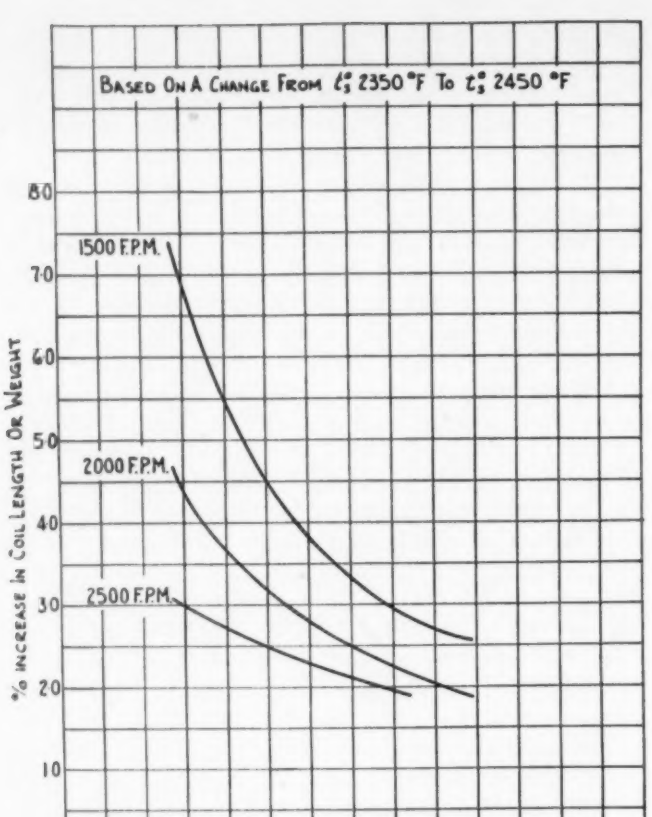


Figure 9 — Chart gives per cent increase in coil length and weight for 100 F increase in soaking time.

are connected by a common entry temperature and rolling time. Their simultaneous consideration will indicate conditions under which the roughing equipment is balanced with the continuous train, so far as production rate and entry temperature are concerned. The resulting coil lengths will be such that all previous considerations will be satisfied. Such a simultaneous solution is shown in Figure 7 and indicates the balanced, ideal coil length for a finishing speed of 2000 fpm. A similar superimposition of Figure 6 on Figures 3 and 5 will give the coil lengths obtainable at 1500 fpm and 2500 fpm respectively.

The influence of the furnace soaking zone temperature on the obtainable coil length is shown in Figure 8. This influence, within the reasonable range of temperatures, is not considerable, a fact which is also supported by practical observations.

The per cent increase in possible coil length, when the soaking zone temperature is changed from 2350 F to 2450 F, is shown in Figure 9. The change in length is such that it will not justify manipulations of the soaking zone temperature unless the furnace capacity is inadequate. Too high a furnace temperature will not be desirable from the point of view of the formation of a tight scale. A safe temperature of 2350 F has been selected as the basis for further considerations.

The equations, developed in this review, have been obtained statistically. They are, therefore, subject to refinement by more statistics. It would be worthwhile to have them examined in other plants of our industry.

"METALLURGICAL ASPECTS IN THE DESIGN AND OPERATION OF A NEW CONTINUOUS ANNEALING LINE"

By A. F. MOHRI

Chief Metallurgist

The Steel Company of Canada, Ltd.

Hamilton, Ontario, Canada

▲ TO solve the metallurgical problems encountered in continuous annealing, various grades of full hard steel, i.e. cold reduced in excess of 80 per cent, were subjected to numerous annealing cycles. An apparatus consisting of an open-circuit thermocouple connected to an electronic temperature recorder was used to determine the exact temperature of the steel during these annealing cycles.

Each sample, consisting of two test strips in the form of an open-circuit thermocouple, was heat treated through a predetermined cycle. At the commencement of the heat treating cycle, the sample was placed in the center of the furnace chamber and supported there by the holding rod in such a manner that the sample was heated uniformly and entirely by radiation. When the sample reached the desired maximum temperature, the furnace door was opened and the sample was quickly moved to a location in the furnace opening where the desired steel temperature could be maintained. Cooling was carried out by fully withdrawing the sample from the furnace and allowing it to cool in still air. If faster cooling rates were desired, the sample was cooled in a moving stream of air, or if slower cooling rates were required, it was suspended in a chamber of pre-heated air. Air cooling was terminated at selected temperatures by quenching the sample in water.

After heat treatment, the test strips were cut free of the wires and holding rod, and the portions of the strips that had been heated during the spot-welding treatment were sheared off. Each of the two strips (2 x 1½ in.) thus obtained was tested on a superficial Rockwell hardness testing machine (1/16 in. steel ball penetrator, 30 kgm load and diamond anvil). A minimum of five indentations per strip (i.e. total of ten indentations) was made according to a definite pattern: one indentation in each corner and one at the center of the long edge opposite the 3/16 in. hole in the strip. The average hardness value of these ten indentations was used to evaluate the effect of the particular heat treatment carried out on the strips. If for any reason the heat treated strips could not be tested promptly, they were stored at 32 F to arrest any possible age hardening which might otherwise have occurred. Because of the small sample size required to obtain uniformity of temperature, only the hardness test could be used.

Any annealing cycle is made up of the following component parts: heating time, soaking time, cooling time, soaking temperature and quenching temperature.

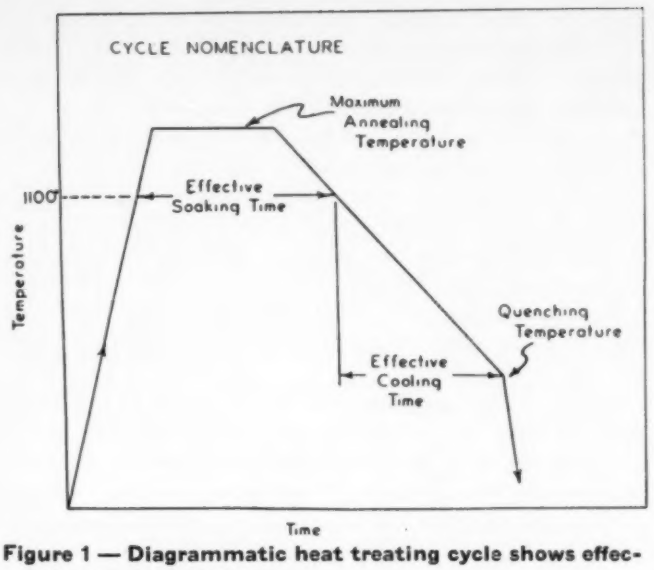


Figure 1 — Diagrammatic heat treating cycle shows effective annealing phases.

The first step in the investigation of annealing cycles was to determine whether these annealing components were effective in influencing the hardness of the steel, and if not, to determine what the effective annealing components are. The procedure followed was to vary one annealing component at a time while maintaining all the others constant. By this method the influence of each factor on hardness could be readily determined.

After finding the effective annealing factors and establishing their influence on the hardness of the steel, the second step in the investigation was to determine the influence of changes in the steel composition. This was carried out by repeating the previous procedure (i.e. by varying each effective annealing factor individually) for a series of steels having different chemical compositions. The effect of the various elements on the hardness of the steel was determined by statistical analysis from the results of this second series of experiments.

During the annealing of steel, three successive microstructure changes occur, each change being accompanied by a decrease in hardness. The first change, known as "recovery," which takes place as the temperature of the steel rises, is the release of the stresses imparted to the steel by the prior cold deformation. At higher temperatures, the second change occurs, in which small grains are nucleated within the cold worked matrix. These new grains grow rapidly until the entire matrix has been absorbed. This change in structure is known as "recrystallization." Over a period of time, and/or with an increase in temperature, the larger of the new grains continue to grow by absorbing any adjacent smaller grains. This third process is termed "grain growth." There is no distinct dividing line between recovery and recrystallization or between recrystallization and grain growth, but each change contributes to the softening of the steel. The major part of the softening takes place during recrystallization.

For the purpose of this paper the "recrystallization temperature" is defined as the temperature at which the first strain-free grains appear within the cold worked metal, i.e. where the hardness of the metal begins to drop suddenly. For any particular metal that has received a definite amount of cold deformation, the recrystallization temperature is directly related to the time of heating, i.e. the faster the rate of heating, the higher the recrystallization temperature.

To determine the recrystallization temperature, a number of samples were heated to increasingly higher temperatures in times of from 15 to 24 seconds, and then cooled to room temperature. Photomicrographs of each heat treated sample were obtained. It was apparent from these photomicrographs that the recrystallization temperature is somewhere in the range of 1100 F to 1120 F. Further experiments were carried out, employing shorter heating times (6 to 15 seconds), to see whether this would result in a major shift in the recrystallization temperature range. No marked difference in the range was observed. It was concluded from these experiments that for heating times between 6 and 24 seconds, the recrystallization temperature is almost constant.

The next series of heat treating experiments con-

Figure 2 — Chart gives the influence of the effective soaking time on the hardness of low carbon steel.

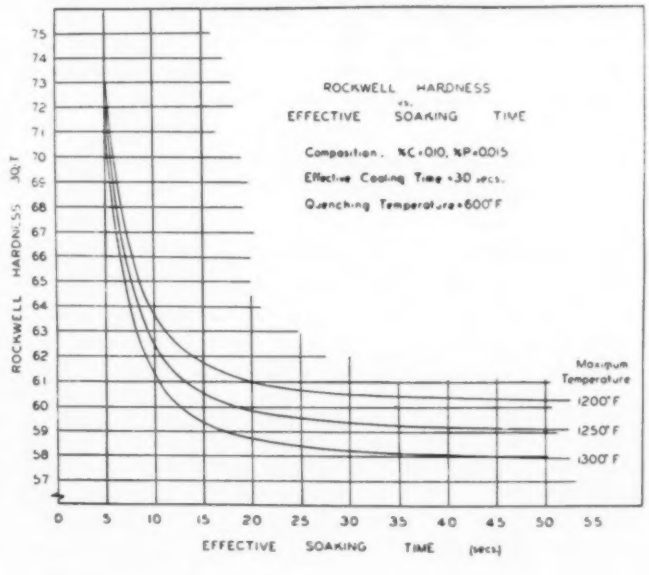
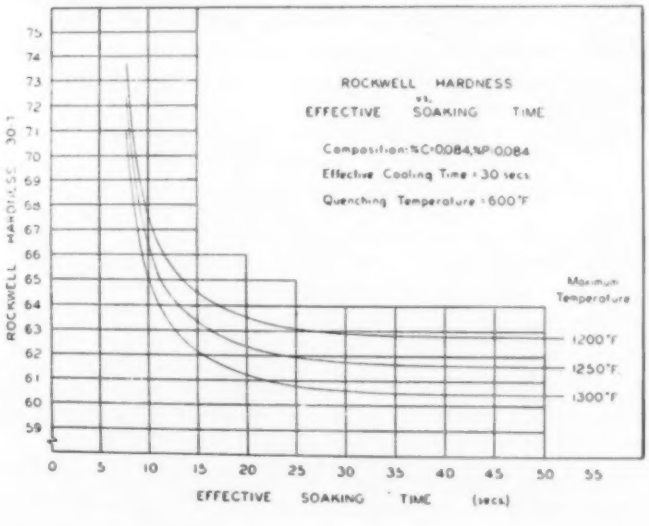


Figure 3 — Chart shows the influence of the effective soaking time on the hardness of low carbon, high phosphorous steel.



sisted of varying the soaking time and the soaking temperature while maintaining the cooling time and the quenching temperature constant. These experiments indicated that the soaking time was not an effective annealing factor, as there was no consistent relationship between the soaking time and the hardness of the steel for each soaking temperature investigated. It was then assumed that the effective annealing factor was the time over the recrystallization temperature.

From the previous experiments on recrystallization, it was reasonable to select 1100 F as being the recrystallization temperature and to assume that this temperature would be constant, since the heating times used throughout the remainder of the investigation were kept within 6 to 24 seconds.

By considering the time over the recrystallization temperature instead of the soaking time, a marked relationship between this new time and the hardness of the steel was apparent. It is permissible to use this time element, which includes both the time for recrystallization and for grain growth, since these two processes are inseparable. The term "effective soaking time" was given to the time over the recrystallization temperature. See Figure 1.

The curves shown in Figure 2 were developed by the use of the following procedure:

1. A sample was heated to a predetermined maximum temperature and held at this temperature for a fixed time. By repeating this procedure using other soaking times, a number of samples was obtained, all having had the same heat treatment except for the duration of the effective soaking time, the range being between 5 to 100 seconds.
2. The above procedure was repeated, using different maximum temperatures in order to provide a number of samples having variations in maximum temperature and in effective soaking time.

The appearance of the curves in Figure 2 suggests that, at the end of about 15 seconds of effective soaking time, recrystallization is nearing completion and that grain growth is starting. From these curves it will also be seen that for times greater than 25 seconds, no further extensive softening can be effected through grain growth without resorting to very long effective soaking times. This retarded grain growth section of the process may be termed the "grain growth shelf." Thus, the minimum effective soaking time permissible to ensure a completely annealed structure was found to be 25 seconds.

In the case of high phosphorus steels, it appears that the time for the apparent completion of recrystallization is longer (about 18 seconds) than it is for low phosphorus grades (15 seconds). See Figure 3.

From Figures 2 and 3 it will be seen that an increase in maximum temperature of 50 F decreases the hardness of the steel by approximately one point Rockwell 30-T. The reason for this is that the maximum temperature reached by the steel governs the equilibrium grain size that can be obtained, i.e. the higher the maximum temperature, the larger the grain size obtained in any given time; thus, the higher the temperature, the softer the steel.

By heat treating Steel No. 5 (see Table I) for effective soaking times (abbr.: E.S.T.) within the range 25 to 80 seconds, the actual hardness values, as shown in Figure 4 were obtained. It is apparent from Figure 4 that a minimum hardness value is obtained when maximum temperatures in the neighborhood of the lower critical temperature (i.e. 1333 F) are used, and that an abrupt increase in the hardness took place when the steel had been heated above 1333 F. This phenomenon may be explained as follows:

Once the temperature of the steel exceeds the lower critical temperature, austenite grains begin to grow within some of the ferrite grains. If, shortly after the start of this grain formation, the steel is cooled rapidly to subcritical temperatures, the new austenite grains will transform back to ferrite, resulting in more ferrite grains than were originally present. Thus, for a steel heated into, and cooled out of, the critical region, the amount of grain refinement taking place will depend upon the rate of heating and the rate of cooling through the transformation temperature. G. Sachs and coworkers maintain that at an annealing temperature of 1400 F the hardness begins to decrease again. They believe that at this temperature the grain refinement caused by the rapid transformation on the one hand, and the increased austenite grain growth due to higher annealing temperatures on the other hand, nearly balance each other.

Since annealing temperatures above the critical (1333 F) may yield a finer grained steel than temperatures below the critical, thereby increasing hardness, no extensive experimental work was carried out at these higher temperatures.

The linear relationship of maximum temperature versus hardness applies only within the temperature range of 1170 to 1333 F. Below a maximum temperature of 1170 F, higher hardness values would be obtained than would be indicated by extrapolation of the

TABLE I

Analyses of the Steels Used in the Experiments

Steel[2]	C[3]	P	S	Mn	Cu	Cr	Ni	Sn	Mo	N
1	0.075	0.014	0.031	0.37	0.039	0.025	0.028	0.006	0.004	0.002
2	0.076	0.013	0.029	0.45	0.038	0.016	0.019	0.006	0.004	0.003
3	0.081	0.017	0.031	0.40	0.035	0.021	0.018	0.006	0.004	0.002
4	0.084	0.084	0.025	0.34	0.042	0.015	0.025	0.008	0.004	0.003
5	0.094	0.014	0.028	0.50	0.057	0.025	0.024	0.006	0.004	0.004
6	0.134	0.015	0.030	0.56	0.051	0.015	0.030	0.007	0.004	0.004

[2] Rolled from "bottle top" ingots.

[3] Average of at least ten determinations.

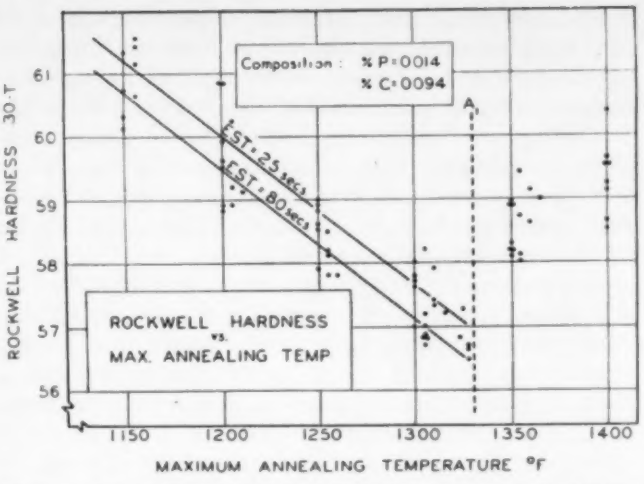


Figure 4 — Chart gives the influence of the maximum annealing temperature on the hardness of low carbon steel.

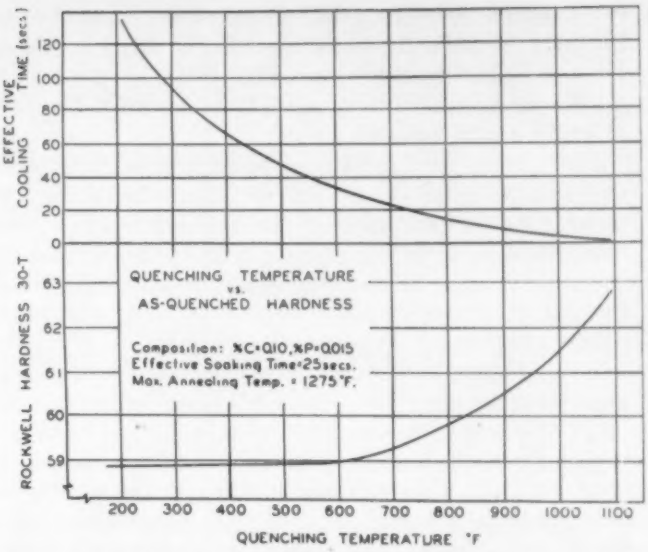


Figure 5 — Chart gives the influence of the quenching temperature on the hardness of low carbon steel in the as-quenched condition. The upper curve shows the effective cooling time that had elapsed for each quenching temperature used.

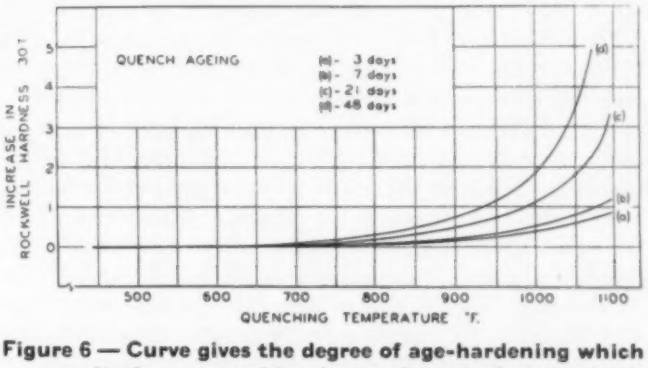


Figure 6 — Curve gives the degree of age-hardening which results from quenching low carbon steel at the indicated temperatures.

lines in Figure 4. Annealing temperatures below 1170 F may be used, however, but the relationship of one point Rockwell 30-T change per 50 F shift in maximum temperature, no longer applies.

Aging is a metallurgical phenomenon, taking place over a period of time, which increases the hardness and the strength and decreases the ductility of steel. The generally accepted primary cause of aging can be explained as follows: carbon has a greater solubility in ferrite at high temperatures than at lower temperatures. If all of the carbon present in a saturated solid solution at a high temperature is retained in solid solution at room temperature by quenching, a supersaturated solid solution of carbon in ferrite is formed. The steel will attempt to reach equilibrium conditions by precipitating the excess carbon out of the solution as submicroscopic carbides. This precipitation causes the change in the physical properties of steel.

Heat treating experiments were carried out to determine the maximum quenching temperature for low carbon steels, this temperature being defined as the highest possible temperature from which the steel may be quenched without subsequent aging taking place. The annealing cycles used in this investigation consisted of an effective soaking time of 25 seconds, a maximum temperature of 1275 F, and a constant rate of change of cooling followed by a quench at a predetermined temperature. The only variable throughout these annealing cycles was the quenching temperature. Each sample treated in the above manner was tested for hardness in the "as-quenched" condition and again after 3, 7, 21 and 48 days had elapsed. The change in hardness of the steel over periods of longer than 48 days was not determined, since a period of 48 days sufficed to show that aging did occur in the samples quenched from the higher temperatures. Figures 5 and 6 show the relationships obtained by means of these quenching experiments.

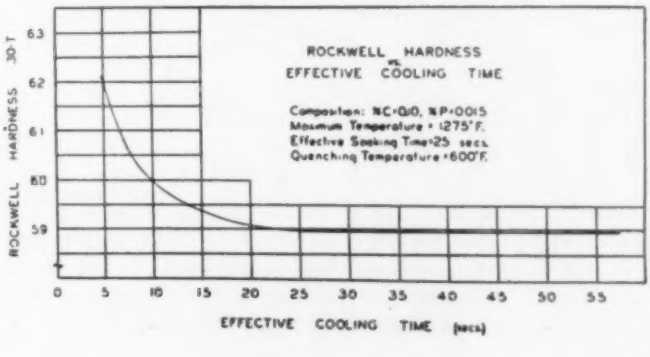
The degrees of quench aging shown in Figure 6 are representative only of grades of steel with compositions similar to those suitable for tin plate manufacture, and only for the type of heat treatment described.

In Figure 5 it will be seen that the hardness of the steel increases progressively as the quenching temperatures used increase. This increase in hardness is the result of carbon being retained in solid solution.

It will be further seen from Figure 5 and from Figure 6 that 600 F is the maximum quenching temperature permissible. The 600 F maximum quenching temperature is in fair agreement with the iron-carbon equilibrium diagram which shows that ferrite can hold nearly the same amount of carbon in solid solution as it can at 600 F.

The effective cooling time is defined as the time required for the steel to cool from 1100 F to the quench-

Figure 7 — Chart gives the influence of the effective cooling time on the hardness of low carbon steel.



ing temperature. The minimum effective cooling time, in turn, is defined as the shortest effective cooling time that can be used from 1100 F to the maximum quenching temperature, i.e. 600 F, without the risk of aging occurring.

The cycles used in the experiments to determine the minimum effective cooling time were similar to those used in determining the maximum quenching temperature, with the exception that the quenching temperature was maintained constant at 600 F, whilst the effective cooling time was varied. The results of these experiments are shown in Figure 7.

From Figure 7, the minimum effective cooling time appears to be about 25 seconds. With effective cooling times of less than 25 seconds, the as-quenched hardness begins to increase due to the retention of carbon in solid solution. This increase in hardness is similar to that produced by quenching from temperatures above 600 F, and therefore the steel may be expected to age when effective cooling time is less than 25 seconds.

Since the minimum effective cooling time is 25 seconds, the effective cooling time of 35 seconds used for the 600 F quench in the previous experiments would have no influence on the hardness. It is concluded, then, that the start of the increase in as-quenched hardness at 600 F is entirely due to quenching at this temperature and not in any way due to the time of cooling prior to the quench.

The minimum effective cooling time of 25 seconds is only applicable to the types of steel used and to the manner in which these steels were treated in this investigation. The reason for this stipulation is that for the given heat treatments received by these steels, the carbon present as carbides was not all dissolved. The carbon that remained out of solid solution acted, during cooling, as points of nucleation upon which the dissolved carbon could precipitate. Had there been no points of nucleation for the precipitation of the dissolved carbon, longer cooling times would have been necessary for the prevention of age-hardening.

The qualitative effect on hardness of some of the constituents in steel can be reasoned by fundamental atomic theory. First of all, these constituents can be divided into two classes: those that form a substitutional solid solution, e.g. copper, chromium, nickel, tin and molybdenum, and those that form an interstitial solid solution, e.g. carbon, hydrogen and nitrogen. In a substitutional solid solution, the atoms of the solute metal replace those of the solvent metal without unduly changing the atomic arrangement of the solvent metal. An interstitial solid solution is marked by the presence of the foreign atoms occupying the voids between the solvent atom sites.

If the atomic arrangement of a metal is disturbed, significant strain is set up within the metal. Careful X-ray measurements by several investigators of the atomic arrangement for solid solutions have shown that, with an increasing amount of solute atoms, there is a regular increase in the distortion of the stable atomic arrangement, and in the mechanical property of hardness; it has, in fact, been possible to correlate hardness with extent of lattice distortion.

If the atoms of the constituents that enter into the steel as substitutional solid solutions have similar diameters to the iron atom, there will be only a slight disturbance within the lattice structure. If any constituent that enters into solid solution has at atom diameter widely differing from that of iron, however, there will be much distortion and hence the annealed steel will have a greater hardness. Thus, to determine those elements present in annealed steel which cause a significant increase in hardness, it is simply a matter of comparing their atom diameters with that of iron. For the residual elements, nickel, chromium, copper, molybdenum and tin, only molybdenum and tin exert a strong influence on hardness.

For interstitial solid solutions, lattice distortion will result if the solute atom size is greater than the size of the void left between the iron atom. This is the case when the steel is quenched from above 600 F. The carbon atoms remain between the iron atoms by forcing the iron atoms lightly out of their stable positions. This distortion is the cause of the increased as-quenched hardness in the samples quenched from temperatures above 600 F. Under stable conditions, i.e. adequate cooling time, however, the carbon atoms precipitate out of solid solution as hard carbide particles. The effect of nitrogen may be assumed to be very similar to that of carbon since their atom radii are smaller.

Figure 8 — Curve gives the influence of carbon content on the hardness of low carbon steel.

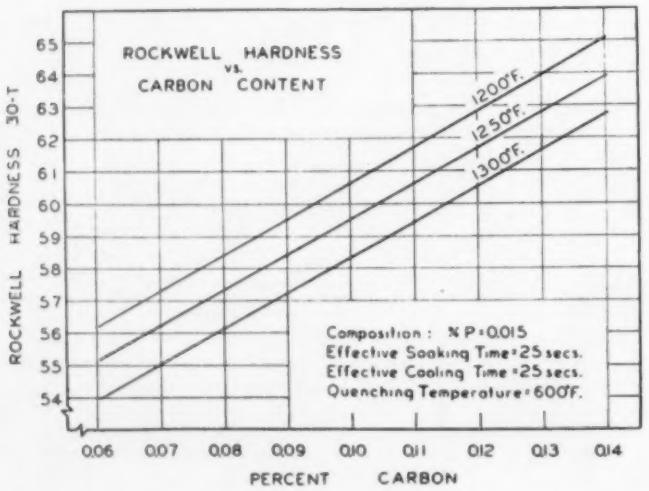
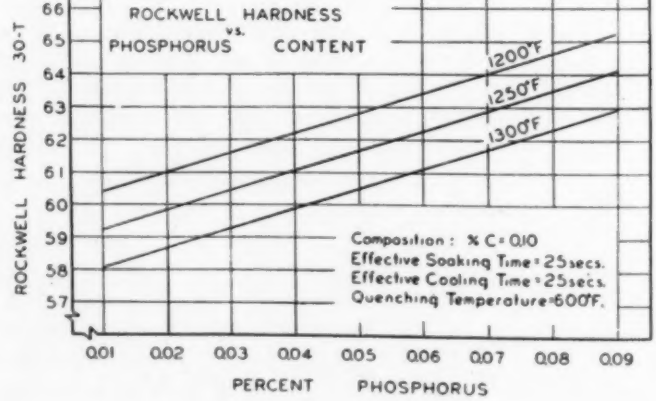


Figure 9 — Curves give the influence of phosphorous content on the hardness of low carbon steel.



To determine the influence of carbon, manganese, nitrogen, phosphorus, tin and molybdenum on the hardness of steel, another series of experiments was carried out following the previously mentioned procedure. Amongst the steels used, as seen in Table I, there was only a small variation in the tin, molybdenum and nitrogen analyses; hence, the effects of these elements on hardness could not be determined quantitatively. For two of the remaining constituents, carbon and phosphorus, it was found that for each 0.01 per cent increase in carbon and 0.02 per cent increase in phosphorus, there was approximately one point increase in Rockwell 30-T hardness (see Figures 8 and 9). The last constituent to be considered, manganese, did not appear to have any detectable influence on the hardness of the steels.

It must be realized, however, that the effect of the elements carbon and phosphorus was based only on six compositions and, therefore, their quantitative effect on hardness must be viewed as being only an approximation, particularly in the case of phosphorus contents which were not evenly distributed throughout the range.

The various relationships that have been mentioned in the foregoing paragraphs have been determined by the statistical method of multiple correlation. The combined effect of the factors considered in these various relationships is represented by the following equation:

$$R_{30\text{-}T} = 75 + 0.035\,\frac{(100)^2}{(EST)} - 0.0233\,(T\ max.) + \frac{20}{(ECT)} + 0.0127\,(ECT) + 110.6\,(\%\ C) + 60.9\,(\%\ P)$$

Where $R_{30\text{-}T}$ = Rockwell hardness value
EST = Effective soaking time
T max. = Maximum soaking temperature
ECT = Effective cooling time
% C = Carbon content
% P = Phosphorus content

The above equation explains 85.6 per cent of the variance that occurred in the Rockwell hardness values obtained. This equation is not valid for steel quenched at temperatures of above 600 F or for steels with high phosphorus contents that have been heat treated for effective soaking times between 0 and 20 seconds.

After temper rolling, the hardness of continuous annealed steel for tin plate will be within the specified hardness range 62/68 Rockwell 30-T, if the as-annealed hardness was in the range 60/63 Rockwell 30-T.

If a furnace has provision for adequate effective soaking time and cooling time, and for a sufficiently low quenching temperature, a change in maximum strip temperature alone would bring about the desired change in hardness. This point is demonstrated in Figure 10. By adjustments in the maximum temperature, the entire range of carbon content permitted in Type MR steel can be continuously annealed, and still meet the above-mentioned hardness specification. Since Type MR steel meets the required hardness specification (See Figure 10) there is no necessity for

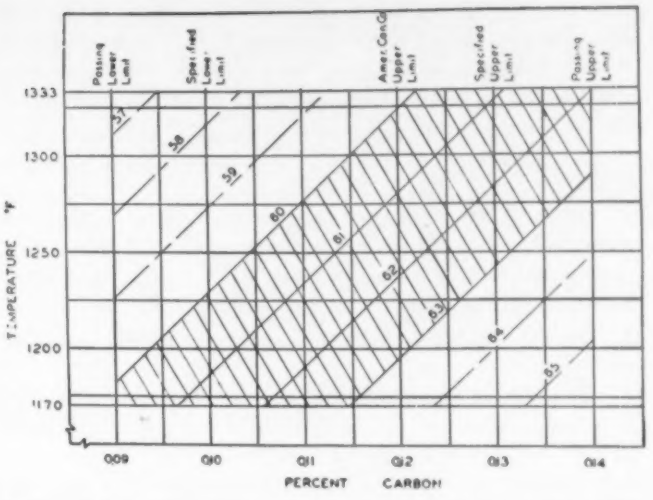


Figure 10 — Nomogram shows how to get same hardness value through changes in the maximum annealing temperature for steels with different carbon contents. Shaded sections of nomogram give the best hardness range to maintain in order to obtain the specified hardness, after temper rolling, of MR type steels. Effective soaking time is 25 seconds and phosphorous content is 0.015 per cent.

employing special steelmaking practices such as the increasing of the nitrogen content, which tends to increase the final hardness of the steel.

The relationship of time and temperature for continuous annealing, as established in this paper, is obviously of great value in the designing and operation of continuous annealing furnaces. In the operation of continuous annealing furnaces, however, a difficulty arises in attempting to apply these relationships. The main difficulty encountered is the inadequacy of the instrument commonly used for measuring the temperature of a moving strip. This instrument, the radiomatic potentiometer, will indicate the true temperature of the strip only if the exact emissivity of the strip is known. The exact emissivity is very difficult to determine because it varies with the temperature and with the nature of the radiating surface. It is not possible to determine, with exactness, the temperature of the strip at any point in the furnace. This means that the effective soaking time, the effective cooling time and the quench temperature cannot be precisely determined. Nevertheless, the relationships established in this paper will assist in maintaining close control of the annealing process by providing a basis for ascertaining the causes of high and low hardness values which may arise from time to time, and for the correction of these possible variations.

SUMMARY

1. The "recrystallization temperature" of low carbon steel appears to occur somewhere within the temperature range 1100 F to 1120 F when fast heating times associated with continuous annealing are used.

2. "Effective soaking time" provides a more satisfactory explanation of hardness change during annealing than does the usual so-called "soaking time." Actually, soaking time, i.e. the time at maximum temperature, has little influence upon the hardness of steel, two to

four seconds at maximum temperature being sufficient. The "minimum effective soaking time" is 25 seconds.

3. The hardness of low carbon steel decreases progressively as higher annealing temperatures are used, up to a maximum temperature of 1333 F. Each 50 F rise in temperature reduces the hardness by about one point Rockwell 30-T.

4. The relationship of maximum temperature to hardness is not linear for temperatures below 1170 F. Annealing temperatures below 1170 F may be used, however, but a larger increase in hardness may be expected for a given decrease in temperature in this non-linear region.

5. Maximum temperatures in the ranges 1333 to 1400 F seem to increase the hardness. Above 1400 F, however, the steel may again become softer.

6. Cooling time from maximum temperature to 1100 F appears to be of secondary importance. Further experimentation, however, may be warranted from the fundamental point of view to investigate its importance more completely.

7. The "maximum quenching temperature" is 600 F.

8. The "minimum effective cooling time" is 25 seconds.

9. Increasing amounts of carbon, nitrogen, phosphorus, tin and molybdenum in the annealed steel may be expected to cause a marked increase in hardness. An increase of about one point Rockwell 30-T hardness may be caused by increasing the carbon content by 0.01 per cent or the phosphorus by 0.02 per cent.

10. The effect of the various components of an annealing cycle on the as-annealed hardness of steel has been established quantitatively.

11. The relationships, as determined in this paper, have been found to be in close agreement with the actual conditions encountered in our production unit.

"BLAST FURNACE OXYGEN OPERATIONS"

BY JULIUS H. STRASSBURGER

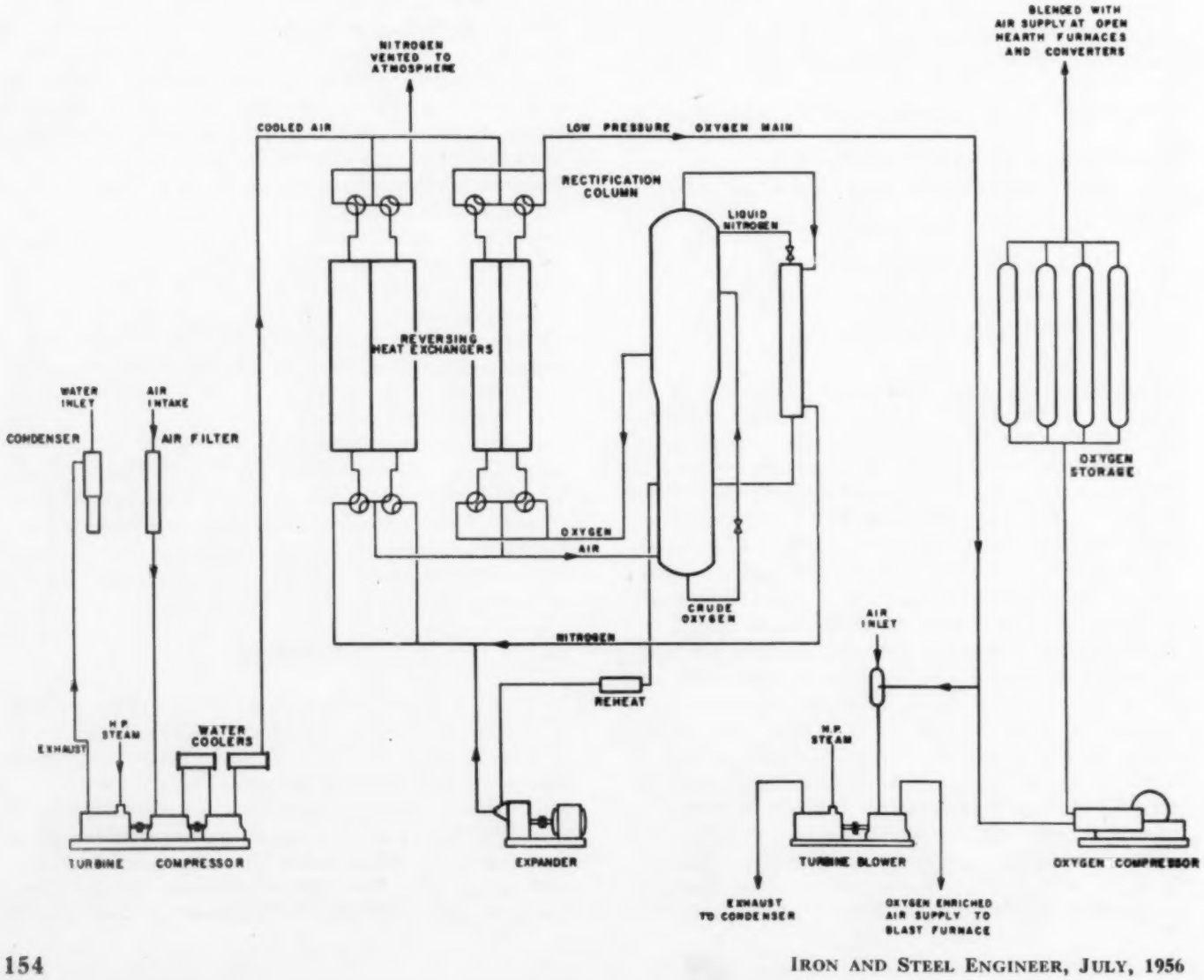
Assistant Vice President

National Steel Corp.

Pittsburgh, Pa.

▲ THE Weirton Steel Co. Division of the National Steel Corp. started the operation of a tonnage oxygen plant in February 1951, and has operated this plant for the past five years making an average daily production of about 450 tons of oxygen for blast furnace and steel

Figure 1 — Schematic diagram shows layout of 450-ton oxygen plant at Weirton Steel.



plant usage. During this five-year period the oxygen plant has produced 650,000 tons of 95 per cent purity oxygen, of which about 550,000 tons have been used for the enrichment of the blast for blast furnace iron production. The balance of the oxygen produced has been used for open hearth lancing, open hearth combustion, the enrichment of the blast for bessemer converters, and other steel plant uses. This paper will deal particularly with the oxygen plant operation and the use of oxygen for enrichment of the blast for blast furnace operation.

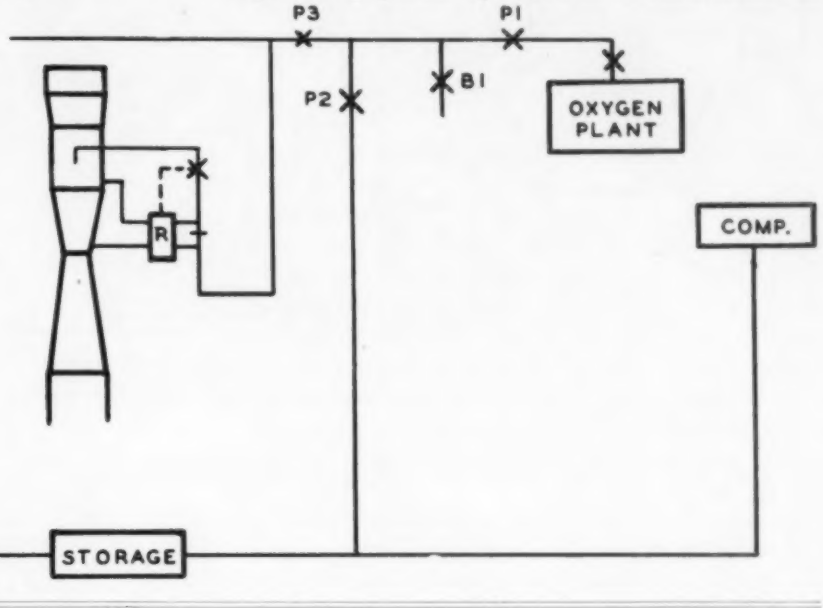


Figure 2—Flow of oxygen from oxygen plant to one of the turboblowers is shown by the diagram.

The oxygen plant is rated 450-ton and uses reversing heat exchangers of aluminum construction for both cleanup of air and for precooling the air to liquefaction temperature. Figure 1 is a diagrammatic sketch showing the flow of air, nitrogen and oxygen in the tonnage oxygen plant. After developing the initial operating technique for this plant, its operation has become a routine practice, and with the experience accumulated we find that the production of tonnage oxygen is a relatively simple, straightforward process.

The oxygen plant, including the oxygen compressors, is operated on each shift by one operator and one helper. On daylight there are a repairman and helper who take care of both the tonnage oxygen plant and the high purity plants operated in another location. A superintendent and assistant superintendent are in charge of the tonnage and pure oxygen operations.

Figure 2 shows diagrammatically the oxygen flow from the oxygen plant to one of six turboblowers. The oxygen leaves the plant through an 18-in. line, where it is reduced in pressure by a regulator P1 to about two-lb pressure. An automatic bleeder, noted as B1, is set for three-lb pressure. P2 is a makeup control which maintains two-lb pressure in the 18-in. line supplying the makeup oxygen from the 300-lb compressor storage system. This is a necessary control so that uniform oxygen can be obtained at all times on the turboblowers during reversals and other periods of upset flow. The oxygen then passes through automatic pressure control P3, which reduces the pressure to one lb. The one-lb oxygen then is handled through duplicate sets of controls on each turboblower. The turboblower controls consist chiefly of a ratio regulator designated as R. This ratio regulator controls the flow of oxygen into the turboblower intake in exact proportion to the flow of air through the main turboblower venturi control meter. The control of the oxygen is accurate and follows all variations in turboblower settings. Charts give daily records of the following:

1. Oxygen plant high pressure steam flow and temperature.
2. Oxygen flow from tonnage plant.
3. Air flow to oxygen plant—oxygen pressure from plant.

With the introduction of oxygenation of the blast we also installed complete moisture control of the blast in order to be able to control accurately and vary the amount of moisture in the blast dependent on the quantity of oxygen enrichment. This has been found

TABLE I
Typical Hourly Operating Log Data

Oxygen flow, cfhr	473,000
Production oxygen purity, per cent	96.0
Effluent nitrogen purity, per cent	98.2
Crude nitrogen purity, per cent	97.2
Air flow, cfm	41,000
Switch time — oxygen, min	3
Switch time — nitrogen, min	7
Liquid levels — low pressure column, in.	96.5
Liquid levels — high pressure column, in.	26
Pressures, psig	
Compressor interstage	38.5
Compressor discharge	80
Pressure air to column	77
High pressure column	76
Low pressure column	7
Nitrogen from exchanger	0.7
Oxygen to exchangers	6.8
Expander inlet	61.5
Temperatures, F	
Air to reversing exchanger	Plus 68
Cold air header bottom reversing exchanger	Minus 279
Air from liquefiers	Minus 286
Effluent nitrogen low pressure column	Minus 310
Cold nitrogen header at bottom reversing exchangers	Minus 290
Effluent nitrogen from reversing exchangers	Plus 65
Oxygen from low pressure column	Minus 288
Effluent oxygen from reversing exchangers	Plus 67
Expander generator current, amp	100

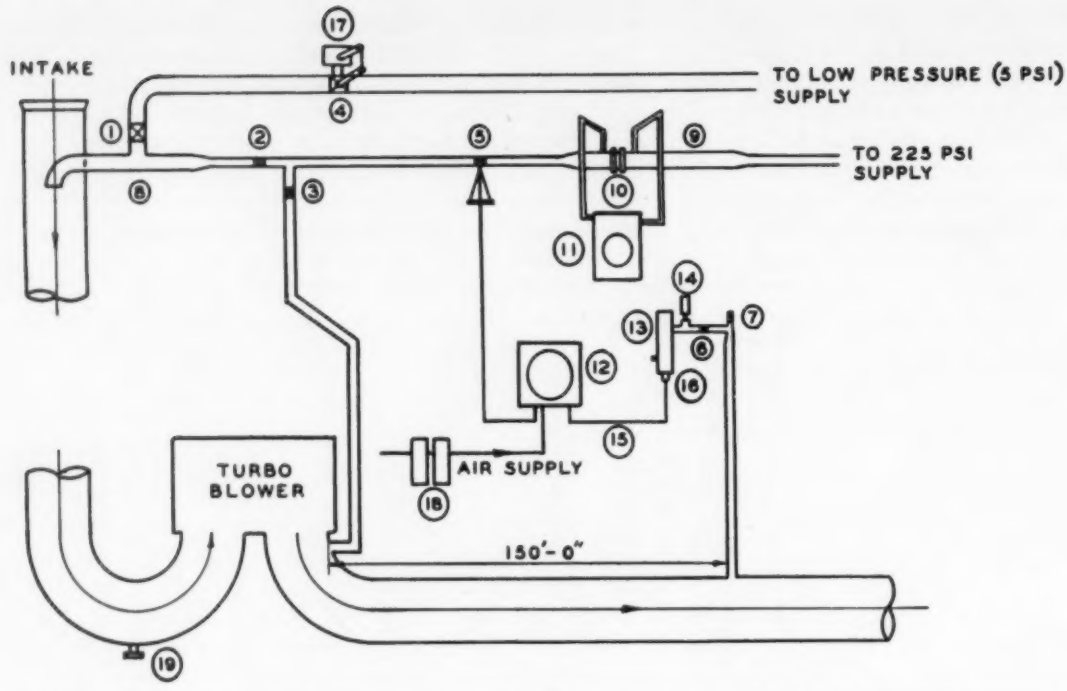


Figure 3 — Automatic control is applied to both low pressure and high pressure steam for introduction into the cold blast system.

1. Manual valve between low pressure steam system and entry pipe to the turbo.
2. Manual valve between high pressure steam system and inlet to the turboblower.
3. Manual valve between high pressure steam system and outlet of turboblower.
4. Motor operated valve, to pass 5000 lb of steam per hour at 2 psig. This valve controls the amount of low pressure steam to the inlet of the turbo.
5. Pneumatic operated valve which is used to automatically add steam to the turbo either ahead of or after according to how the valves (2) and (3) are set.
6. Manual valve to control the amount of air sample through the dew cell.
7. Manual gate valve to control the amount of air sample bled to atmosphere for temperature control of the dew cell and to be used for blowing the dirt out of the sample line.
8. Entry pipe for steam into the air intake of the turbo.
9. Orifice pipe to meter the steam used on this application.
10. Orifice plate.
11. Flow meter for steam flow.
12. Dew point recorder-controller, pneumatically operated.
13. Dew cell box.
14. Thermometer to measure the air sample temperature.
15. Five conductor cables which connects the dew cell to the recorder.
16. Dew cell.
17. Motor drive, pushbutton operated to add low pressure steam ahead of the turbo.
18. Air cleaner for instrument air.
19. Drain on bottom of elbow ahead of turbo. For removal of condensate from the air stream.

to be a necessary and advantageous control, and one that has worked out quite favorably in blast furnace operation. With proper moisture control, the melting zone in the blast furnace can be controlled so as to prevent sticky furnace operation and to maintain a free flow of the bosh gases up through the blast furnace stack. The moisture control is illustrated in Figure 3, which shows automatic control of both low-pressure or high-pressure steam for introduction into the cold blast system. Table in Figure 3 gives key to operation of system. This control operates as follows:

About 100 ft downstream from the turboblower a connection on the air discharge line delivers an air sample through an insulated sample line to a dew cell. A small amount of air is passed through this dew cell at constant temperature. The cell determines the amount of moisture in the air and this result is recorded on a recorder controller in grains per cu ft. Any variation in the set amount of moisture desired varies the amount of steam delivered to the turboblower intake so as to maintain an accurate moisture control with an automatic valve actuated in the steam lines for control purposes. The steam can be added either on the suction or on the discharge side of the turboblower. A steam meter is used to measure the steam flow both as a check on the moisture control and also for accounting purposes. In addition to the moisture control for each turboblower, there is also a moisture recorder to measure and record the natural moisture in the atmosphere by using a separate dew cell system. With the record of natural moisture, we have an additional check with the steam meter on the amount of moisture that is being added by the controls. Normally, with 2 per cent oxygen enrichment, the moisture is controlled at about seven grains per cu ft in the turboblower discharge. The amount of moisture varies usually with the amount of oxygen enrichment, For example, the following tabulation shows the relationship between moisture and enrichment:

Oxygen Enrichment	Moisture in Grains Per Cu Ft
1.0	5
1.5	6
2.0	7
2.5	8
3.0	9 to 10

In general, the automatic controls of both oxygen and moisture have made possible the accurate ratioing and control of the oxygenation of the blast to the blast furnaces. Charts give the following information:

1. Air flow and pressure blast furnace turboblower discharge.
2. Oxygen flow to turboblower suction.
3. Natural moisture air intake—gr per cu ft.
4. Controlled moisture in cold blast main.
5. Steam flow for moisture control.
6. Hot blast pressure at No. 1 blast furnace.

The use of steam as an addition to the blast for moisture control, in addition to providing the proper moisture content for control of the blast furnace smelting operation, also has the function of delivering hydrogen and oxygen into the blast furnace bosh without accompanying dilutants such as nitrogen. Steam contains about 89 per cent oxygen and 11 per cent hydrogen. In disassociating the moisture in the blast furnace, about 1.13 tons of steam are required to disassociate one ton of oxygen, which reacts with the coke for the formation of CO. The remaining 11 per cent of the steam in the form of hydrogen makes available this highly reducing gas for blast furnace reduction reactions. The source of oxygen from steam is a cheap means of introducing additional oxygen into the furnace without dilutants. For example, with steam at $1.00 per ton, the oxygen delivered to a blast furnace by moisture disassociation costs only $1.14 per ton of oxygen.

BLAST FURNACE OPERATION

During the past five years we have used oxygen enrichment up to a range of 3 per cent. However, with the size of the oxygen plant operating at Weirton, with an average production of about 450 tons of oxygen per day, there has been about 400 tons available for blast furnace enrichment. We have found it advantageous to spread this 400 tons over all of the operating furnaces rather than to concentrate it on one furnace. Approximately 65 tons of oxygen are required per furnace per day for each 1 per cent of enrichment, so that with an average of 1.5 per cent oxygen on each blast furnace, the four furnaces have a total requirement of 400 tons of oxygen per day. The use of oxygen enrichment of the blast has resulted in an increased iron tonnage in proportion to the oxygenation of the blast. For example, with 1.5 per cent enrichment, there is a 7 per cent increase in equivalent wind volume with a resultant 7 per cent increase in iron tonnage. With 2 per cent enrichment the increased wind volume of 9.5 per cent again results in a 9.5 per cent increase in iron tonnage. Table II shows the enrichment of a 76,000 cfm wind volume from zero up to 3 per cent oxygen enrichment.

TABLE II

Equivalent Wind Volumes of Oxygenated Air

Oxygen enrichment, per cent	Equivalent wind volumes
0.0	76,000
0.5	78,000
1.0	79,700
1.5	81,500
2.0	83,300
2.5	85,100
3.0	87,000

It will be noted that at 2 per cent enrichment a 76,000 cfm wind volume actually has an equivalent wind volume of 83,300 cfm of natural air equivalent. With oxygen enrichment, the actual velocities up the stack with the 83,300 cfm equivalent blast, is only equal approximately to the velocities that would be obtained with 76,000 cfm of normal air blowing.

ECONOMICS OF BLAST ENRICHMENT

The economics of oxygen enrichment of the blast can be summarized as follows:

1. The use of oxygenated air results in increased iron production with a lowering of the "cost above materials."
2. The increased tonnage which is obtained with no increase in gas velocities up the stack results in a proportionate decrease in flue dust in pounds per ton of iron.
3. With a coke saving of 25 to 50 lb per ton of iron with 2 per cent oxygen enrichment, the top gas temperature is about 50 F less and cooling losses, etc., are reduced per ton of iron with greater throughput.
4. The CO/CO_2 ratio is maintained in about the same proportion with oxygen enrichment as with normal air. However, the Btu of the top gas is increased due to the reduction in nitrogen with oxygen enrichment. Where a furnace would normally have a top gas of about 90 to 92 Btu per cu ft with 2 per cent oxygen enrichment, the top gas has a heating value of 98 to 100 Btu per cu ft. This results in a higher gas credit to the blast furnace per cu ft of wind blown and also produces a more desirable heating value gas for use in boilers, stoves, soaking pits and coke oven heating. Table III is a typical analysis of top gas with and without oxygen enrichment.

TABLE III

Typical Analyses of Top Gas With and Without Oxygen Enrichment

Without oxygen enrichment		With 1.5 per cent oxygen enrichment	
CO_2	14.0	CO_2	15.0
O_2	0.0	O_2	0.0
CO	26.4	CO	27.2
H_2	2.9	H_2	3.4
N_2	56.7	N_2	54.4
Btu	94.4	Btu	98.6
CO/CO_2	1.89	CO/CO_2	1.81

5. The fact that additional equivalent wind can be blown by oxygen enrichment means that the steam is not increased on the turboblower which continues to operate at its normal wind volume. This results in a saving of turboblower steam which partially compensates for the steam cost of the oxygen plant.
6. The cost of producing oxygen consists mainly of steam and labor. With the 800-lb, 800 F steam supply at Weirton, approximately 3100 lb of

steam are required per ton of oxygen produced. The oxygen cost, including amortization of the plant, is well under the $5.00 per ton oxygen cost figure.

In regard to the effect of oxygen enrichment on the blast furnace linings, we have had considerable experience at Weirton, inasmuch as No. 1 furnace was blown out in 1953, No. 2 furnace in the fall of 1954 and No. 3 furnace was blown out in March of 1956. These furnaces had the following iron production on the linings when blown out:

Furnace No.	
1	3,115,000 tons
2	3,336,000 tons
3	3,493,000 tons

There was definitely no detrimental effect noted on either the hearth, bosh or stack linings. No. 1 furnace had a ceramic hearth and No. 2 and No. 3 furnaces carbon hearths.

BLAST FURNACE OPERATING DATA

Table IV shows the principal dimensions of the four blast furnaces at Weirton:

TABLE IV

Principal Dimensions of the Four Blast Furnaces at Weirton

	Furnace No. 1	Furnace No. 2	Furnace No. 3	Furnace No. 4
Hearth diameter	25 ft 6 in.	25 ft 6 in.	25 ft 6 in.	25 ft 6 in.
Bosh diameter	28 ft 6 in.	28 ft 6 in.	28 ft 6 in.	28 ft 6 in.
Stock line diameter	19 ft 4 in.	19 ft 4 in.	19 ft 6 in.	19 ft 6 in.
Bell diameter	14 ft 2 in.	14 ft 2 in.	14 ft 6 in.	14 ft 6 in.
Height iron notch	91 ft 6 in.	92 ft 0 in.	100 ft 0 in.	100 ft 0 in.
Working volume bottom closed bell to center line iron notch — cu ft	39,340	39,560	43,740	43,740

Table V is a summary of a month's operating data for No. 2 furnace:

TABLE V

Summary of Operating Data

Days operated	31
Oxygen enrichment, per cent	1.5
Moisture, gr per cu ft	6.0
Wind blown, cfm	75,000
Equivalent wind, cfm	80,400
Burden	24,800
Number of charges	204
Hot blast temperature, F	1,160
Top heat, F	280
Blast pressure, psi	18.7
Average daily scrap-free iron production, tons	1,426
Coke per ton of iron, lb	1,670
Dry flue dust, lb per ton	80
Delays	0
Iron analysis, per cent	
Silicon	1.10
Sulphur	0.035
Phosphorus	0.300
Manganese	0.95
Btu of top gas	98
Amount of sinter	22.5
Amount of oversize ore	10

SUMMARY

In conclusion, we want to stress first that the operation of the tonnage oxygen plant at Weirton has become a routine operation and the use of the oxygen which is used daily in the blast furnace, open hearth and bessemer departments has contributed to increased iron and steel production in our steel works operations. The use of oxygen has made available another means of controlling blast furnace iron tonnage, and the use of moisture control, in conjunction with oxygen enrichment, has been a means of obtaining a uniform, smooth, economic blast furnace practice.

It is also our opinion that the use of oxygen in the blast furnace and in other steel plant operations will increase greatly in the coming years. In the future, it is possible that radical changes in the method of oxygen enrichment and application to the blast furnaces could result in marked improvements in iron tonnage and reduction in costs.

"STEEL'S DEPRECIATION PROBLEM"

By BENJAMIN F. FAIRLESS

President

American Iron and Steel Institute

New York, N. Y.

▲ EVERY one here realizes that the steel industry has a duty to keep itself efficient. That means it has to maintain its existing capacity in good shape even before it thinks about expanding it to keep up with the growth of the country. The job of replacing the equipment as it wears out or becomes obsolete is a good-sized one just by itself. Since facilities have an average life of about twenty-five years in the steel industry, the normal replacement job, all by itself, amounts to about 4 per cent of our total plant each year. That does not look very big. It is bigger than it looks—especially if you stop to think that all the expansion job that has been done in the industry over the last ten years, amounts to just a little less than 3½ per cent a year.

As we look ahead it is becoming increasingly clear that there are going to be a lot of problems encountered in just staying even. These problems ought not to exist, but the simple fact is that they do. The regular depreciation allowed under the tax laws ought, of course, to be sufficient to cover these stay-even requirements. But the truth is that they are not. The purpose of depreciation is to recover over the lives of facilities the dollars originally invested in them. The dollars when recovered are presumed to be sufficient to buy enough equipment to keep even with the wearing out of existing equipment. And they would be, if there were stability in the buying power of the dollar.

But the simple fact is that the buying power of the dollar has not been stable. We have had 15 years of continuous cost inflation; and facilities for the steel industry now cost immensely more than they used to.

There is no official index measuring the price changes of the facilities the steel industry buys. But the index of construction cost gives what we regard as a pretty fair indication of the cost trend.

If the year 1940 is taken as 100; it took $2.73, in 1955, to buy what could be bought for $1.00 in 1940. But the regular depreciation allowed for a facility built in 1940 is based on the $1.00 spent in 1940 instead of the $2.73 or more it now takes to replace it. The difference is regarded as profit and is taxed as such.

In this period there was no year in which the cost failed to rise; and since World War II the increase has been very rapid. Over the fifteen-year period the rate was approximately 7 per cent per annum compounded. By using this 7 per cent per annum figure, we can get an indication of the over-all inadequacy of depreciation on facilities which have a life of 25 years, and which have been bought in equal physical amounts each year. Each year, of course, the cost of equipment rises by 7 per cent over its cost in the preceding year, and hence—as each year goes by—the depreciation on a facility built in an earlier year becomes less and less adequate. If we add it up for all the facilities, over all the years, it comes out that for each $1.00 of so-called regular depreciation that we get, we actually need $2.15 in order just to stay even. In short, to recover purchasing power under these assumptions, our regular depreciation allowance needs to be multiplied by 2.15.

There are two reasons why this 2.15 is so shockingly large. First, there is the high 7 per cent compound rate of price inflation. Second, the long life of facilities in the steel industry gives this high rate a long time to compound. If the average life of facilities were ten years, instead of twenty-five, the multiple of 2.15 would drop to 1.42. If the life averaged only five years —the multiple would drop to 1.22.

Now while this multiple of 2.15 has been worked out on a theoretical basis, it closely approximates the actual facts in the steel industry today. Thus it is estimated that at 1955 prices, the industry must spend somewhere between a $1,000,000,000 and $1,200,000,000 a year for facilities in order to stay even. This does not include anything for major capacity expansion. Ten years ago the corresponding estimate was from $400 to $500,000,000.

Part of the reason for the big increase that has occurred in the stay-even cost over the past ten years is that capacity was expanded. There is more plant to be kept up. Taking this into account the rise in the stay-even cost has been in the range of from about 5 to 7 per cent a year. These are rates of increase approaching those given by the index of construction costs.

The multiple of 2.15 which applies to the steel industry is undoubtedly larger than that which would be necessary in many other industries that are not so heavily invested in *long-life* facilities. But this only means that industries like steel are caught in an extremely inequitable and unfair situation, because our capital is more heavily taxed away as it turns over more slowly through depreciation.

Thus far we have been dealing with the cost inflation we have already experienced. If we could suppose that this cost inflation had now come to an end we would be less concerned about the erosion of capital, which results from the imposition of high income taxes on what is really depreciation.

But we cannot prudently make such an assumption; for the steel industry's own records clearly show how persistent the course of cost inflation has been. For example, the industry's employment costs per employee hour, and its total costs per employee hour, from 1940 to 1955 have been at the average compound rate of 7.5 per cent per year.

For all industry combined, employment costs represent something more than three-quarters of all costs. So as inflation persists in the nation's employment costs, a paralleling inflation is to be expected in other costs, such as purchased products and services, wear and exhaustion, and taxes. Certainly the records display that our total costs per employee hour have fully kept pace with the steady rise in employment costs. To provide a man with an hour of work and to supply him with all the things necessary to do his work now costs three and a quarter times as much as it did in 1940.

Throughout this entire period there has been no combination of circumstances, in any year, under which employment costs failed to increase. It, therefore, seems probable that cost inflation will continue; and we must assume that it will. This conclusion is fortified if we look at the two basic roots of the new peacetime cost inflation that has been fastened upon us. The first root is the presence of industry-wide labor unions whose power has been clearly demonstrated over the years.

The other root is the national policy which, in effect, requires the Federal Reserve Board to create what might easily prove to be inflationary monetary conditions whenever any serious unemployment threatens. This tends to remove the normal competitive forces that might otherwise serve to check unduly mounting employment costs. That the Federal Reserve Board has so skillfully administered this difficult responsibility of moderating inflation and avoiding serious unemployment is something of which we should all be appreciative.

With this background of continuing cost inflation in mind, let us look ahead briefly to the next five years. I have already estimated that the industry must spend from $1,000,000,000 to $1,200,000,000—call it $1,100,000,000 a year— if it is to provide itself with new facilities as fast as existing facilities are wearing out or becoming obsolete. This is the average amount per year for the next five years; and it assumes that there will be no further inflation whatever in the cost of constructing such facilities.

But, we cannot safely assume that the underlying cost inflation will be halted. Should construction costs continue to rise at the average 7 per cent per annum rate, then we are talking about bigger figures later on. Five years at 7 per cent compounded means a 40 per cent bigger figure. And instead of $1,100,000,000, we shall need $1,500,000,000 dollars five years hence.

Today, we have amortization under certificates of necessity. This amortization on new facilities helps to fill the present gap. When it is added to regular depreciation it gives, temporarily, a truer total of wear

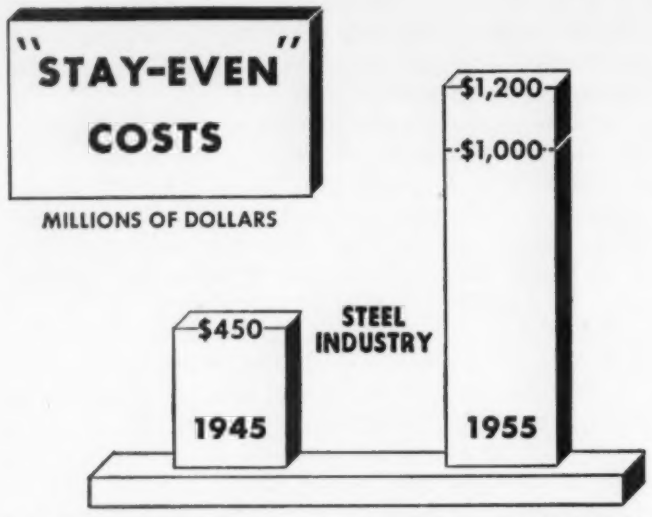


Figure 1 — At present prices, it will cost from $1,000,000,000 to $1,200,000,000 for the steel industry to maintain present capacity or 2.15 times what it would have been in 1945.

and exhaustion on all facilities based on current dollar purchasing power. But when that amortization begins to disappear in 1958-59 the inadequacy of wear and exhaustion amounts will be aggravated.

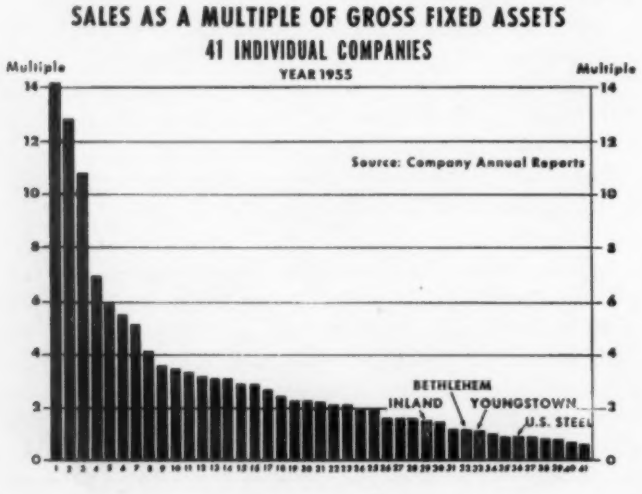
The dropping out of amortization will sharply emphasize the inadequacy of wear and exhaustion in the steel industry at the very time when it should be increasing to be realistic; and so the funds necessary for replacement must be obtained from some other source.

In the absence of adequate wear and exhaustion the other standard internal source of funds for keeping even is income reinvested, and the standard external sources are borrowing money and selling new stock.

To the extent that reinvested income is used for this purpose, such income becomes unavailable for providing needed working capital, for paying off existing debt, and for use in connection with expanding capacity. And, in any event, $2 before taxes is required to do the job of $1 of wear and exhaustion.

Borrowing is one means of financing capital expenditures. Although borrowing for profitable expansion may sometimes be justified, borrowing to cover the erosion of capital is one of the best ways I know of

Figure 2 — It takes more fixed assets per dollar of sales for the steel industry than in most other types of plants.



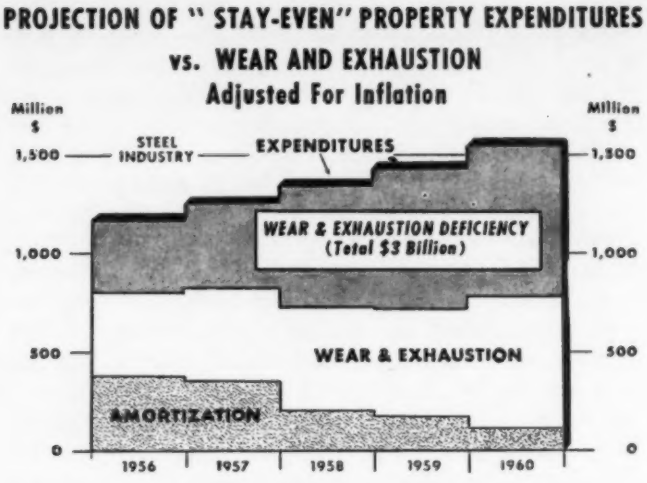
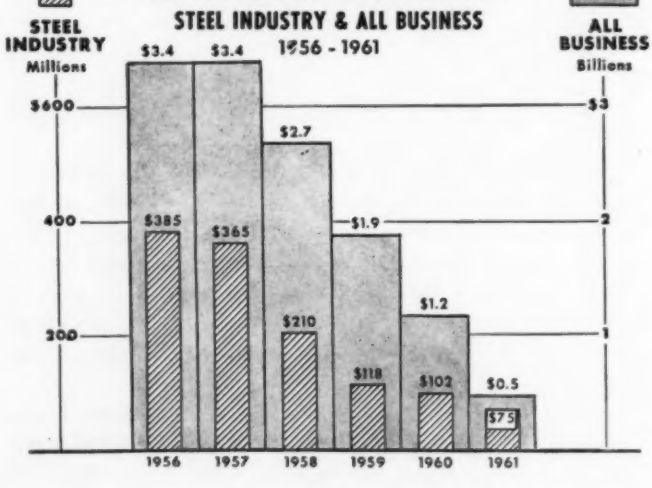


Figure 3 — With inflation at seven per cent compounded, it will take $1,500,000,000 of expenditures to keep the industry at present capacity.

"going broke" in a hurry. We also are confronted by the simple fact that most steel companies just do not have the capacity to borrow, on top of their existing debts, enough money to do the job in this kind of a situation. A third fallacy in borrowing to stay even is that although interest paid is deductible for tax purposes, it is only out of profits after taxes that debt can be paid off. Moreover, debts have a curious habit of coming due at the very times when it is hardest to find the cash with which to pay them. Indebtedness is not good for companies in the "up-and-down" durable goods industries.

On this matter of borrowing there are a few other sobering facts to bear in mind. We know that a brand new integrated steel plant would today cost at least $300 per ton of ingot capacity, or roughly $400 per ton of finished steel capacity. The average steel company's earning rate of approximately 8 per cent on sales works out to something like $10 a ton of finished steel. This is equivalent to 2½ per cent on the $400 a ton investment. To earn that much assumes, moreover, that the new plant would be operated at full capacity all the time. It also happens to be true that one can

Figure 4 — Rapid amortization of present program has been helpful but will soon become a minor factor.



get more than a 2½ per cent yield today, in high-grade, fully tax-exempt, municipal bonds.

Now financing through the sale of new stock is the historical American way, and a completely appropriate means, of acquiring funds for financing new facilities or expanding old ones. It should be reserved for such purposes; for if money is secured through stock sales merely to cover the erosion of existing assets, it only results in the dilution of the stockholders' equity.

From this presentation of the facts and prospects, it is apparent that the problem of financing the stay-even requirements in the steel industry, let alone that of finding funds for expansion, is a most serious one. That problem is greatly aggravated for companies like those in the steel industry which must be heavily invested in long-term facilities, by the heavy taxation of that which is really depreciation, but which under tax law is considered taxable income.

We are not, of course, the only ones aware of this perplexing problem. The Congress has from time to time provided certain depreciation expedients. Thus, during World War II and the Korean conflict, there was legislation to provide "accelerated amortization" on part of the cost of new defense facilities. This permitted the taxpayer to take greater depreciation in the early years of a facility's life. With 60 per cent of a twenty-five year facility subject to amortization, and with the balance subject to regular depreciation at 4 per cent per year, the recovery of the original expenditure amounts to 68 per cent in the first five years.

This has helped temporarily to give a truer total of depreciation on all facilities based on current dollar values. But it automatically guarantees something of a future crisis. Thus when the amortization runs out the situation becomes worse than it was before the amortization provisions were enacted, because the remaining depreciation to be taken in the future is, of course, much less than it would otherwise have been.

In an attempt to stave off this crisis, the Revenue Act of 1954 provided two alternative methods of determining depreciation for tax purposes: the sum-of-the-digits method and the declining-balance method. I do not wish to be grudging in my recognition of the fact that these new methods can prove helpful, but the simple truth is that on twenty-five year facilities they do, only about half the job that accelerated amortization does and at the very time when more of a job is becoming necessary. No one should deceive himself in this matter. Accelerated amortization is very helpful in a temporary sense, but it does not do the whole job. And even if we finally got to the point where *every* property item was being written off in five years, we would still be short of depreciation. The recovery would still have to be multiplied by 1.22 to give us equivalent buying power under a 7 per cent per annum cost inflation rate.

Other countries have done a better legislative job of recognizing the realities of depreciation during cost inflation. France recognized the depreciation problem by taking steps to permit revaluation of certain assets and liabilities. This was first permitted in 1946 and the law was revised several times, the last revision being five years ago. Under this last revision, the cost of fixed assets purchased in 1914 or earlier can be multiplied for depreciation purposes by 194.4. For ensuing years this multiple is graduated downward until it reaches 1.3 for the year 1950. These are the amounts by which so-called regular depreciation may be multiplied to get the amounts deductible for tax purposes. In addition the first year's depreciation may be taken at twice the normal rate for new plant and equipment, and for items of equipment acquired for modernization 10 per cent of the cost may be written off on delivery.

In Great Britain the reducing or declining-balance method is considered the normal depreciation method, with the straight-line method an alternative. Both methods are based on original cost. The annual rate for coke ovens is approximately 16 per cent of the remaining balance; and for iron and steel manufacturing the rate is 9 per cent. In addition, there is an initial allowance of 10 per cent on industrial buildings and 20 per cent for plant and machines. These are taken the first year in conjunction with established rates for various types of fixed assets. Thus, in Britain, the depreciation allowed in the first year on coke facilities is 35.6 per cent, and on iron and steel facilities 29.4 per cent. In the second and succeeding years the depreciation allowed on coke facilities is 16 per cent of the remaining balance. For iron and steel facilities it is 9 per cent.

In Canada, the declining-balance system was adopted in 1949 with specific maximum rates for various groups of fixed assets. For coke ovens, blast furnaces and steelmaking facilities the depreciation allowed for tax purposes is 20 per cent per annum. At this rate 49 per cent of original cost is recovered in the first three years and a residual value of 10 per cent is reached in eleven years. Other manufacturing facilities may be depreciated at 6 and 8 per cent; and other classes of property may be depreciated at from 4 to 40 per cent rates.

In addition, special accelerated depreciation beginning in 1951 can be claimed on assets essential to defense for which a certificate of eligibility is obtained from the Minister of Defense Production. This amounts to 70 per cent over a four-year period for four classes of assets and 50 per cent over the same period for a fifth class.

Our purpose in these comments has been to bring up the grave problem of financing stay-even requirements and to show the part that insufficient depreciation plays in that problem. A heavy responsibility weighs upon us and its weight is increased because of the great tax inequity existing between industries heavily invested in long-term facilities and those who turn over their facilities quickly. Part of our responsibility is to stem as much as we can the inflationary rise in the nation's underlying employment costs. That would prove a service to every one in the land, perhaps most of all to those who work for wages and look forward to pensions. It would reduce the magnitude of the stay-even problem.

The other part of our responsibility is to seek prompt legislative treatment on the problem; and—pending that treatment—to promote a wide-spread understanding of the facts; so that when legislative treatment is given it will be a good and just treatment.

Can Maker Expands Research Facilities

▲ Continental Can Co. has officially opened its $7,000,000 research and development center in Chicago, Ill. Nearly 600 people will work at the new center, which is said to be the largest and most advanced under one roof in the can-making industry.

Located at 76th Street and Loomis Blvd., in south Chicago, the center will service the Company's 41 plants in the metal division. The three-story building, with more than 260,000 sq ft of floor space, is a fireproof structure of reinforced concrete beam and flat slab construction, and of low, modern design.

The building houses a modern library, complete pilot areas for can-making and can-closing equipment, and advanced chemical, physical, and microbiological laboratories. Equipment has also been installed for designing, producing, and testing can-making and closing machines.

The laboratory is complete to an ultra-modern test kitchen and facilities for a taste panel to help develop new products suitable for canning, as well as to perfect metal packaging improvements.

There are also an experimental machine tool shop, 6500 sq ft of controlled temperature storage rooms for testing shelf life, machine design facilities and equipment assembly areas.

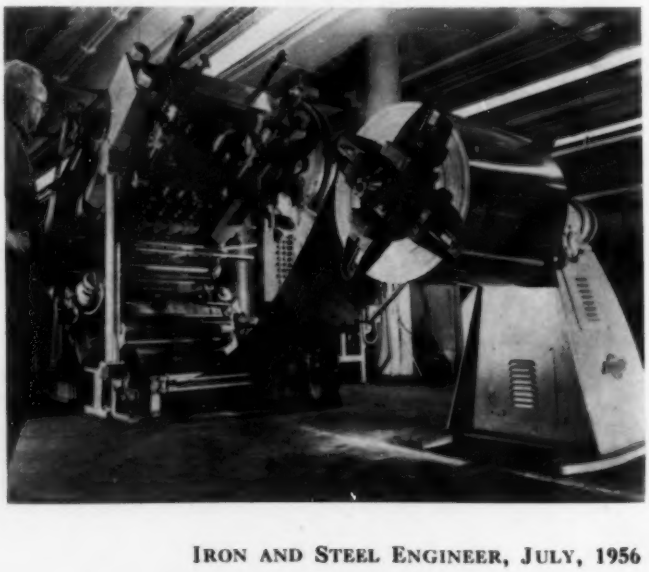
Continental Can Co. owns over 80 plants, mills and other operating units and employs about 32,000 people in the U. S., Cuba and Canada. It is no longer exclusively a can company, but has diversified considerably and more accurately should be called a packaging company. Although approximately two-thirds of the company's dollar volume comes from metal cans, Continental is the largest manufacturer of fibre drums and a leading producer of crown caps, paper cups and containers, steel pails, and decorated kitchenware. In addition to the metal division, the company operates a fibre drum division, a paper board division, a paper container division, a crown (bottle cap) and cork division, and Shellmar-Betner flexible packaging division.

There is also an equipment manufacturing group which makes can-making machinery for the company's use. Cannery equipment is also sold or leased to canners and packers. The company owns The White Cap Company of Chicago, which makes vacuum seal closures. It also controls the following operating subsidiaries: Continental Can Company of Canada, Ltd.; Continental Can Corp., Havana, Cuba; The Container Company, Van Wert, Ohio; and the Wallace Container Company, Santa Ana, California.

The recent acquisition of Hazel-Atlas Glass Co. also puts Continental into the glass container field and further diversifies the company's position in the packaging field. Hazel-Atlas now operates 13 plants in Pennsylvania, West Virginia, Ohio, New York, Oklahoma, California and Alabama, and produces glassware and glass containers for food products, cosmetics, toiletries, beverages and drugs.

Figure 1 — Continental Can Co.'s new $7,000,000 laboratory for research and engineering in Chicago is said to be the largest and most advanced under one roof in the can-making industry. The center includes more than 260,000 sq ft of floor space, to be devoted to the development of new containers, new machinery to make and close the containers, and new products for packaging in metal and related materials.

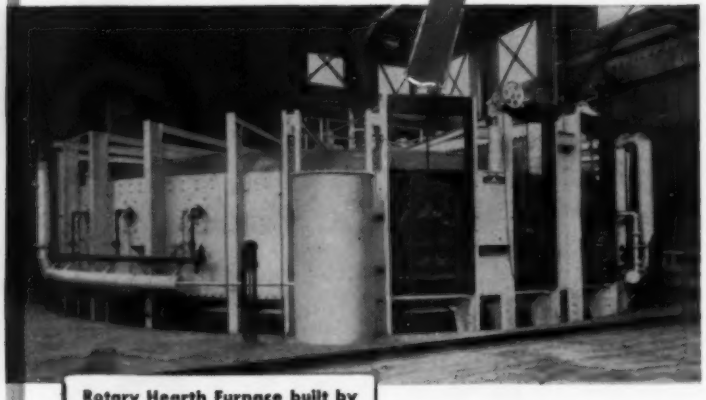
Figure 2 — Equipment in Continental Can Co.'s new laboratory for research and engineering includes this Callahan gang die press. The machine utilizes coils of steel up to 6000 lb instead of sheet stock in the manufacture of can ends at speeds up to 1200 pieces per minute. The use of coiled stock will increase yield and reduce costs.



Four Open Hearth Furnaces designed by Rust for Lone Star Steel Company's modern steel mill at Lone Star, Texas

RUST

First in design and construction of metallurgical furnaces



Rotary Hearth Furnace built by Rust for a Pennsylvania plant

Hundreds of installations, throughout the world, offer convincing proof of Rust's leadership in furnace design and construction. For melting, reheating, or heat treating, you can rely on Rust for economical, automatic, trouble-free furnace efficiency.

A Type for Every Need

OPEN HEARTH FURNACES • SOAKING PITS • CONTINUOUS REHEATING FURNACES • CAR TYPE HEAT TREATING FURNACES • BOX ANNEALING FURNACES • CONTINUOUS PIPE ANNEALING • CONTINUOUS STRIP ANNEALING • GALVANIZING • WIRE PATENTING • ROLLER BOTTOM HEAT TREATING • SPECIAL FURNACES FOR SMELTING, ORE THAWING, POLYMERS DISPOSAL, COAL DRYING, AND OTHER USES.

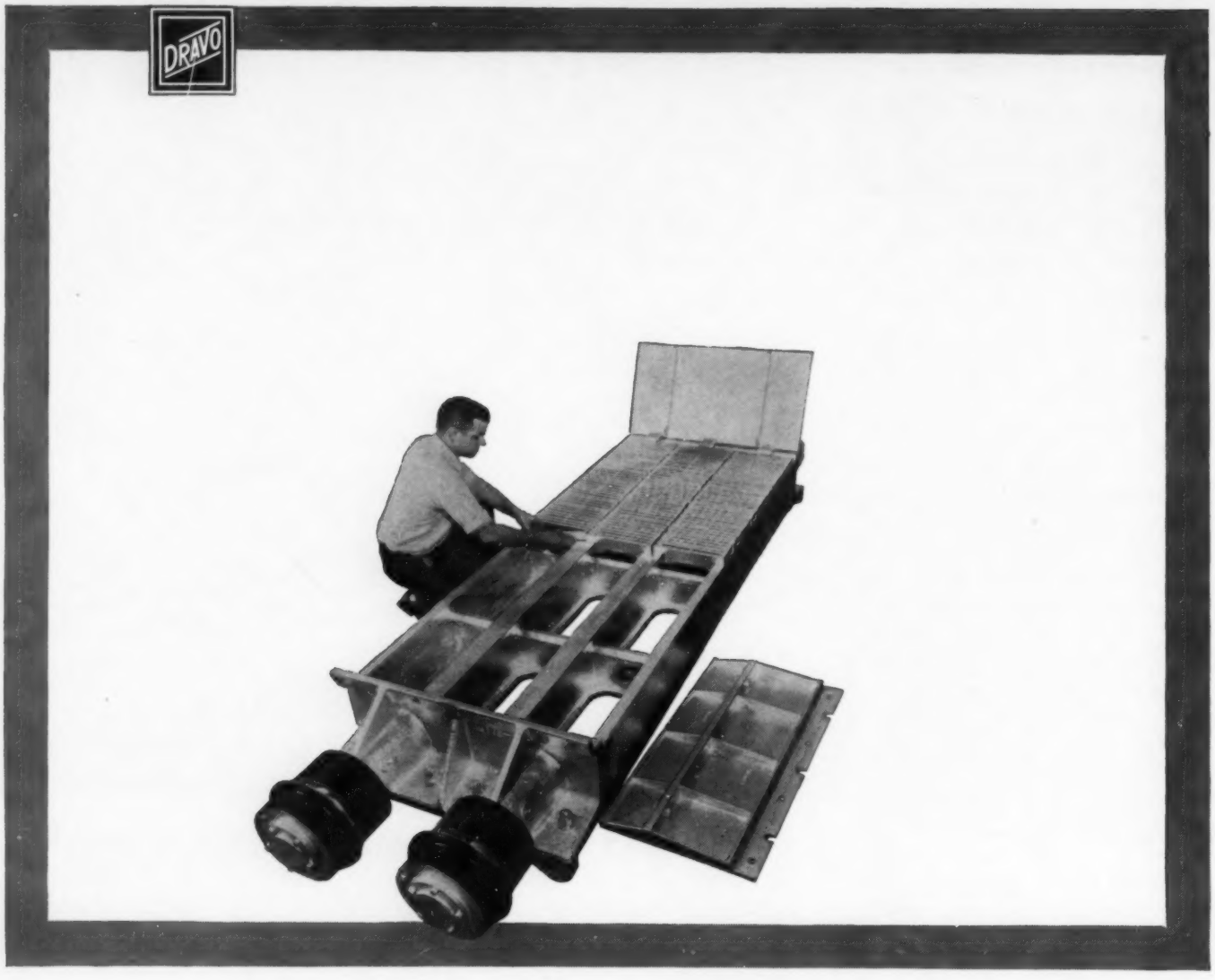
THE WHOLE JOB IS ONE JOB WITH A "RUST PACKAGE CONTRACT"

One contract covers everything from original idea to start-up. One responsibility for design, manufacture, erection and initial operation. One overhead and one profit (with substantial savings to you) on all phases of the work, including wiring and piping.

Rust Furnace Company

Pioneers in Furnace Design

Rust Building • Pittsburgh, Pa.



DRAVO-LURGI

sintering experience . . . ready to work for you

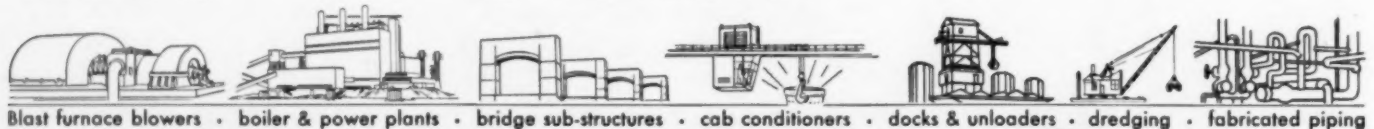
Over 250 sintering plant installations qualify Lurgi as an experienced designer of low-grade ore treatment equipment. In fact, the annual capacity of Lurgi sintering machines on iron ore alone is more than 30 million tons.

This background is now combined with Dravo's engineering and manufacturing facilities to bring the advantages of this advanced design to American industry.

In a major installation recently completed by Dravo, 124 pallets, like the one shown above, are used. Design features of these pallets are the result of Lurgi's 30 years' experience in sintering machinery construction.

For more information on Dravo-Lurgi equipment for sintering, pelletizing or other related ore processing and preparation, write Dravo Corporation, Dept. S-100, Pittsburgh 22, Pa.

DRAVO
CORPORATION



Blast furnace blowers · boiler & power plants · bridge sub-structures · cab conditioners · docks & unloaders · dredging · fabricated piping

foundations · gantry & floating cranes · gas & oil pumping stations · locks and dams · ore & coal bridges · process equipment · pumphouses & intakes

river sand and gravel · sintering plants · slopes, shafts, tunnels · space heaters · steel grating · towboats, barges, river transportation

The Boiler House—

THE STEEL PLANT'S HEART

By GEORGE F. WOLFE
Chief Project Engineer
Dravo Corp.
Pittsburgh, Pa.

▲ REQUIREMENTS for steam at the new steel plant built by McLouth Steel Corporation at Trenton, Mich. predicated the use of two boilers with a capacity of 120,000 lb each per hour. To provide standby or auxiliary power, a total of three boilers was installed. Each is designed to operate at a normal load of 120,000 lb, with steam pressure of 625 psig and temperature of 825 F at the superheater outlet. The boilers are two-drum, water-tube type fired with blast furnace gas or oil or a combination of the two fuels. After several months of operation, the preliminary amount of 240,000 lb per hr of steam requirement was verified for normal usage, but sudden peak demands showed that it was preferable to operate all three boilers at about 80,000 lb each, rather than attempt to fire up the third boiler for such demands. In accordance with standard safety practices, these boilers were furnished with welded steel casings to prevent gas leakage.

Water supply for the boilers is taken from the Detroit River and treated before using. Raw water is delivered to two hot lime softeners having a total capacity of 48,000 gph. The sedimentation tanks, as shown in Figure 1, are a vertical cylindrical type 15 ft-0 in. diam with 20 ft-0 in. straight side height, equipped with ladders and platforms for ready access to all points of operation. After leaving the hot softeners, the water passes through four 8 ft-0 in. diam by 4 ft-0 in. straight side filters and is then taken through four 5 ft-0 in. diam by 5 ft-0 in. straight side hot zeolite softeners for final hardness removal. At this point in the system, feed water booster pumps lift the treated water to a jet-tray type deaerator designed for an outlet capacity of 412,500 lb per hr, sufficient for all three boilers and with deaerated water storage for 10 minutes of operation at full load on all boilers.

After deaeration, the feed water flows by gravity to the boiler feed pumps. Two geared turbine driven pumps with a capacity of 900 gpm each are used so that one pump can supply all boilers at full load.

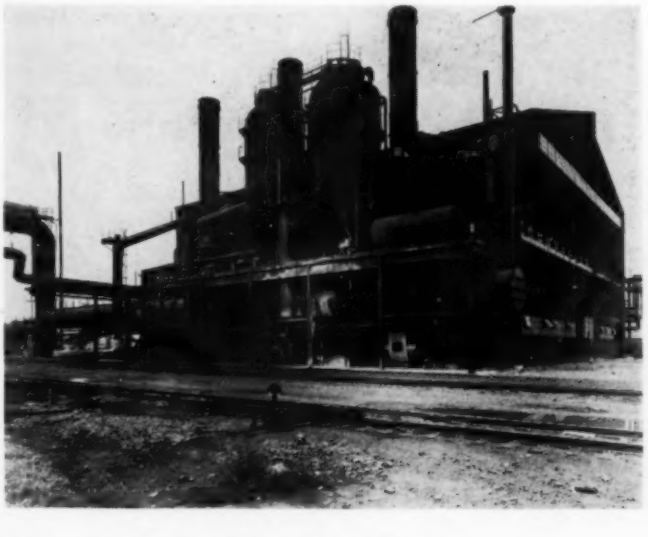
In addition to the water treating system, sulphite and phosphate systems were installed for the introduction of these chemicals by hand control as desired.

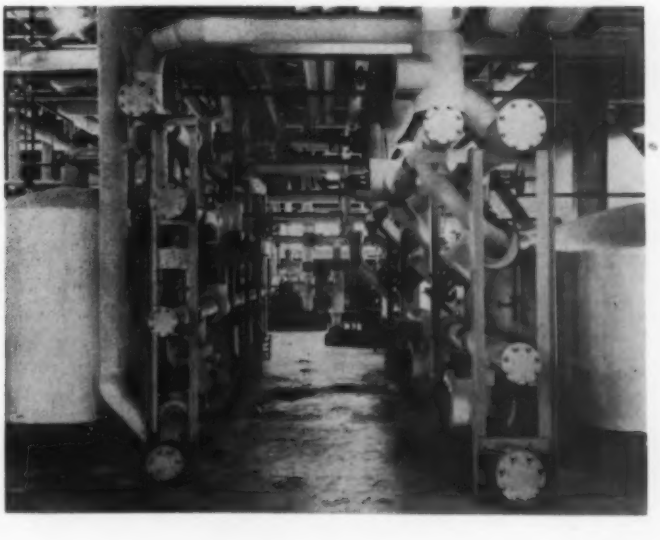
STEAM DISTRIBUTION

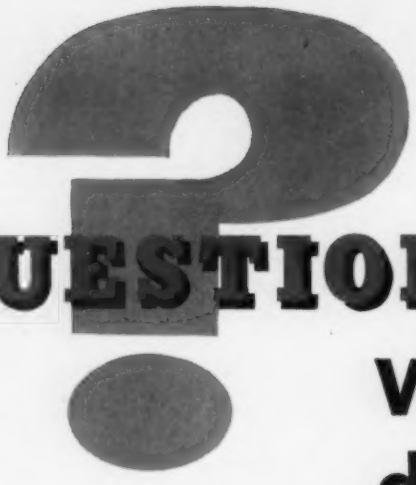
High pressure steam from the boilers is used to drive turbines operating a 4000-kw generating set, two turboblowers, three induced draft fans, two boiler feed pumps, one fire pump, and one pilot fire pump. The turbines driving the generator and induced draft fans exhaust into a 150 psi system from which all other auxiliaries are driven. This system also supplies mill process steam. With exception of the turbines driving the blowers, which are condensing, and the fire pump which has atmospheric exhaust, all the low pressure equipment exhausts at 10 psi. About 40,000 lb per hr of high pressure steam is taken to an air separation plant where, after being used to drive compressors, about 28,000 lb are restored to the boiler house as condensate.

A pressure reducing and desuperheating system is provided to reduce 625 psi steam to 150 psi to augment the 150 psi steam supply. In order to make provision for sudden demands of 150 psi steam for the blast furnace without curtailing the normal supply

Figure 1 (left) — General view of boiler house shows Cochrane hot lime softeners and deaerating heaters on outdoor platform at operating floor level with blast furnace gas header below. Figure 2 (right) — Filters and hot zeolite softeners are in two rows with all valves on central aisle for ease of operation.







QUESTION:

Why is CORHART 104 different from other basic refractories?

ANSWER:

Corhart 104 is different from other basic refractories because of its method of manufacture. It is made by electrically melting conventional raw materials at 4450° F., and then pouring this refractory liquid into pre-formed molds where it solidifies, forming a homogeneous, interlocking crystalline refractory structure.

QUESTION:

What Advantages Are Available With CORHART 104?

ANSWER:

Corhart 104 offers the advantages of non-connecting porosity, interlocking structure and greater mechanical strength at operating temperatures. Its high density makes it more impermeable to gases and slags. Its absence of connecting porosity gives it a greater degree of corrosion resistance.

QUESTION:

When may we discuss possible use of CORHART 104 in your operation?

QUALITY ECONOMY ENDURANCE

CORHART 104
ELECTROCAST
REFRACTORY

The words "Corhart" and "Electrocast" are registered Trade Marks which indicate manufacture by Corhart Refractories Company, *Incorporated*.
Corhart Refractories Co., *Incorporated*, 1602 West Lee Street, Louisville 10, Kentucky, U. S. A.—Telephone CYpress 4471.

Figure 3 (left) — Two turboblowers, each rated at 110,000 cfm of air at 30 psi, furnish wind for the blast furnace. A 4000-kw turbogenerator is shown in the background, together with the electrical switchgear. Part of boiler bay can be seen at left above the turboblower

centralized control panel. Figure 4 (right) — General view of the Babcock & Wilcox boilers and operating panels for the turboblowers. Both turboblower throttles face this central aisle for ease of operation.

to the plant, a separate 50,000-lb pressure reducing and desuperheating station was provided to draw directly from the high pressure steam supply.

Exhaust steam at 10 psi is used to heat and deaerate the water and to supply heat for the hot lime softeners. In case of any deficiency of 10 psi steam, a pressure reducing valve furnishes make-up steam from the 150 psi system. Excess heat is released to atmosphere through two 14-in. Cochrane multiport relief valves.

OIL REMOVAL SYSTEM

Condensate returned from the air separation plant is contaminated with oil which must be removed before returning to the feed water system. The oily condensate is introduced into three 3 ft-6 in. x 4 ft-0 in. straight shell height filters together with pre-formed floc from a 30-in. diam x 30-in. high preparation tank. After filtering, the condensate goes into a 1,000-gal storage tank from which it is pumped to the deaerating feed water heater.

TURBOBLOWER AND CONDENSERS

Two DeLaval blast furnace turboblowers are provided. Each blower is capable of delivering 110,000 cfm of air measured under inlet conditions of 14.4 psia and 100 F against a discharge pressure of 30 psig. Each blower consists of four stages with 60-in. diam inlet opening and 48-in. diam discharge opening, and is driven by a DeLaval 15-stage steam turbine. The turbines operate on steam at a throttle of 600 psig and 800 F, with 2-in. Hg absolute exhaust pressure. A normal speed of 2800 rpm develops approximately 12,400 bihp.

Each turboblower is provided with an 8500 sq ft, C. H. Wheeler surface condenser designed for 87,670 lb per hr of steam and an absolute pressure of 2-in. Hg when furnished with 9350 gpm of 75 F cooling water. Each condenser has two 3-in. two-stage condensate pumps rated at 220 gpm at 175-ft discharge head to return the condensate to the deaerating feed water heater. Both pumps are turbine driven and one is also equipped with motor drive for emergency operation. The condensers are spring mounted with rigid bolted connections to the turbine exhausts.

The turboblowers are arranged, as shown in Figures 3 and 4, with throttles facing a central aisle. Operating panel boards are located at the end of this aisle so that the operator is in position at all times to observe various gage readings. For ready access to the condensers, a stairway is provided between the turboblowers as shown in the photographs.

TURBOGENERATOR

In order to utilize available blast furnace gas to the fullest extent, a 4000-kw Westinghouse turbine generator was installed. This unit, running at 3600 rpm, consists of a noncondensing type turbine designed for steam conditions of 600 psig, 800 F at the throttle and exhaust pressure of 150 psig. The turbine is direct-connected to a 4000-kw, 0.80 power factor, 6900-volt, 3-phase, 60-cycle generator with an exciter and generator air cooler. It is a base load unit supplying part of the power requirements for the hot metal area, and is provided with means for synchronizing with the local utility power supply.

SWITCHGEAR

In addition to the normal boiler house requirements for switchgear, a large number of units were installed to feed the hot metal area. Switchgear is provided to receive 6900-volt current from the 400-kw turbogenerator and two outside utility ties. This current is then fed to the river pump house, blast furnace area, oxygen inversion process plant and a 2300-volt ore bridge substation located in the boiler house. All incoming feeders to the switchgear and outgoing lines for distribution are carried in metal trays supported from a lower floor.

CONBUSTION CONTROL

The combustion control system is designed to control the boilers fired with blast furnace gas and using oil as a supplementary fuel. The system is arranged to accommodate firing of

coke oven gas as an additional supplemental fuel.

The control system is built around a master steam pressure regulator and blast furnace gas pressure limiting regulator, both of which are common to the complete system for all three boilers. The steam pressure regulator measures pressure in the main steam header and develops an air loading pressure which is transmitted to each of the individual boiler controllers. The blast furnace gas pressure regulator measures pressures in the blast furnace gas header. By the use of these regulators and additional control equipment, normal firing conditions are maintained as long as steam demand and blast furnace gas pressure remain constant.

If, however, blast furnace gas pressure drops to a predetermined minimum, additional fuel is introduced in the form of oil and the two fuels then are used together. When the blast furnace gas pressure becomes too low, the gas is cut off and combustion is continued using only oil. Before gas is again turned on, the lines are steam-purged. Firing controls are tied in with the operation of dampers on forced and induced draft fans. These dampers will close at low air demand to hold the fan turbine drives at a satisfactory point above the stalling speed.

Lawrence COPPER COOLING PLATES
FOR TROUBLE FREE PERFORMANCE
Don't risk faulty cooling plates during your next campaign. Replace with Lawrence Copper Bosh and Mantle plates for dependable, trouble-free, long run performance.
Made from pure copper with the know how gained from 68 years in serving many of America's large steel plants, Lawrence Cooling Plates always last through the campaign. Send your specifications today.
Highest Quality and Dependability Since 1888
PURE COPPER CASTINGS
Tuyeres • Tuyere Coolers
Cinder Notches
Valve Gates and Seats
BRASS AND BRONZE CASTINGS
(Heavy type—1 to 2 ton)
Bearings • Machinery Bronze
Bars and Bushings
In the Heart of the Pittsburgh District!
LAWRENCE COPPER & BRONZE CO.
ZELIENOPLE, PA.
BOX 246 • PITTSBURGH DIST. • PHONE 774

STRUCTURE

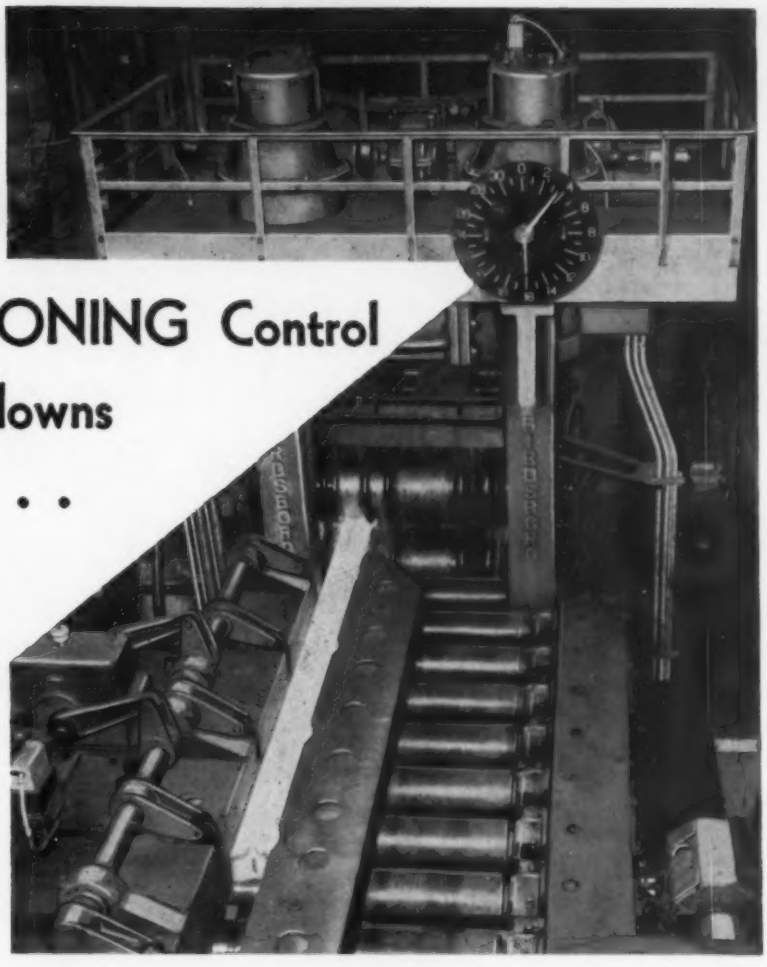
The boiler house and blower building is a two-story steel framed, pile supported structure approximately 135 ft square. A 20 x 80-ft wing houses the switchgear and a 1000-cfm air compressor. The reinforced concrete second floor is supported on steel framing with all upper platforms of tri-lok gratings. The building is covered with corrugated asbestos protected metal and has continuous louvers for roof ventilation.

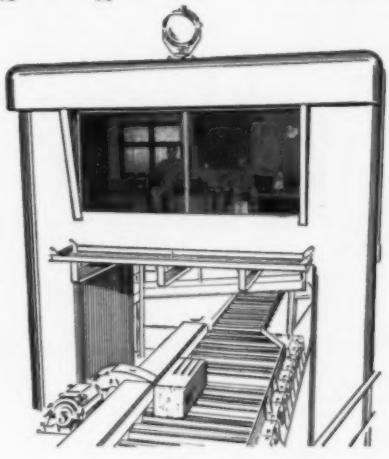
Boilers, turboblowers and the turbogenerator are mounted on the second floor at an elevation 24 feet above the ground floor. The boilers are supported on the steel framework of the building. Turboblowers and the turbogenerator are carried on independent pile supported reinforced concrete foundations brought up to the second floor level. With exception of forced draft fans on the second floor, all auxiliary equipment is located on the ground floor. This arrangement is most beneficial in expediting erection. It eliminates conflict between installation of major equipment on the second floor and erection of auxiliaries and piping under the floor.

On the boiler house side of the building, the second floor is extended as an outside concrete paved platform which supports hot lime softeners and the deaerating feed water heater. At the opposite side of the building, a steel plated platform is carried out at the same level to support turboblower air intakes and discharge lines. This arrangement provided ready access to a majority of the main equipment on one floor level and facilitates operation. Access doors to the outdoor platform also serve as emergency exits in case of gas leakage in the boiler house.

Now... EC&M

AUTOMATIC-POSITIONING Control sets blooming mill screwdowns to *pin point* accuracy . . .





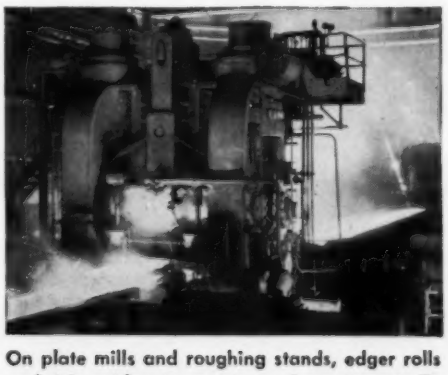
Reduces roller's tasks 1/3

•—•

New operators learn faster

•—•

Accurate drafts reduce rejections



On plate mills and roughing stands, edger rolls and side guide movements can be automatically coordinated with screwdown movements.

Indexes *automatically* from pass to pass to speed rolling and cut costs . . .

To meet the challenge of ever-increasing costs, rolling mill management-teams are turning to automatic operation of screwdowns and associated drives. Precise roll drafts give a higher quality product and new operators become seasoned in a shorter time. Removing the need to coordinate the screwdown with mill reversal enables the roller to concentrate on the manipulation of main motor and work tables for faster and more efficient operation.

The roller pushes a momentary-button only once for each pass, and the rolls are driven to the exact pre-selected settings . . . no overtravel with subsequent inching into position. The operation is entirely automatic for each complete rolling schedule.

This EC&M Automatic-Positioning Screwdown Control system is readily applied to ferrous and non-ferrous mills. New Booklet 9250 fully describes this control and shows many interesting installations. Write for your copy.

6127

SQUARE D COMPANY

EC & M DIVISION . CLEVELAND 28, OHIO

TREADWELL

LADLES

HOT METAL

HOT METAL TRANSFER

BESSEMER

OPEN HEARTH

ELECTRIC FURNACE

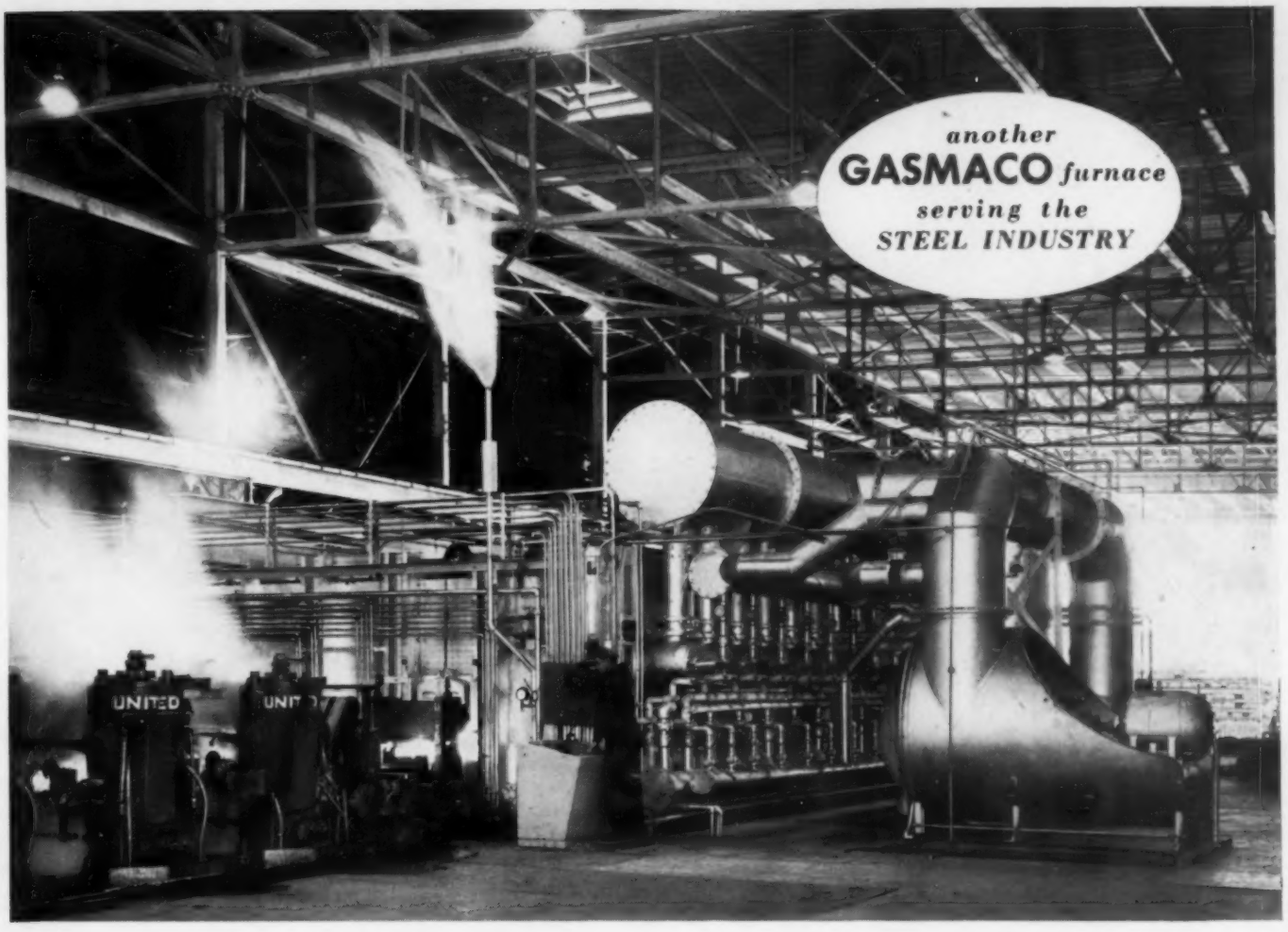
FOUNDRY

Open Hearth Charging Ladle

TREADWELL CONSTRUCTION COMPANY

PLANT AND MAIN OFFICE - MIDLAND, PA.
BOX 20

PITTSBURGH NEW YORK CHICAGO



BILLET HEATING

60-ton Furnace at Wickwire Spencer Steel Division, The Colorado Fuel and Iron Corporation

On this Gas Machinery furnace, reverse flowing of spent gases prevents pile-ups at charge end. Gases pass over the billets and back under before being discharged.

Special holding burners eliminate problems normally encountered in resuming operations after a mill delay.

This furnace is supplied with recuperation . . . has modern combustion and control equipment . . . is designed to suit the mill layout.

GASMACO pusher-type furnaces range up to 150 tons — single-zone, double-zone, triple-zone, five-zone. THE GAS MACHINERY COMPANY, 16128 Waterloo Road, Cleveland 10, Ohio. In Canada: The Gas Machinery Co. (Canada) Ltd., Hamilton, Ontario.

Check first with GASMACO for latest industrial furnace designs.

THE **gas machinery** COMPANY

GAS PLANT EQUIPMENT
AND INDUSTRIAL FURNACES

IT'S NOT WORTH THE CHANCE —CLEAN IT RIGHT

Equipment that operates at less than peak efficiency eats into your company profits. Chemical cleaning can help stop these losses—but only when it's done by experts. Unless you rely on experts, you're taking a chance with your men and valuable equipment.

Dowell engineers understand your cleaning problems and they have the *experience* needed to solve them. Thoroughly trained, they're backed by Dowell's 15 years' experience in removing troublesome scale deposits from virtually every kind of equipment in every kind of industry. They're aided, too, by a completely modern, fully staffed and excellently equipped *research* laboratory.

But, expert cleaning goes beyond keeping your equipment in top condition. Dowell considers the safety of company personnel at every step of the operation. The safest possible working procedures are worked out with your safety personnel.

Call Dowell. Our engineers are always ready to discuss chemical cleaning problems with you. There's no obligation. Or write Dowell Incorporated, Tulsa 1, Okla., Dept. G-29.

chemical cleaning service for industry **DOWELL**

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

Date-line Diary...

June 1

▲ The AISC reports shipments of fabricated steel for April, 1956 totaled 289,616 tons, bookings totaled 378,937 tons, leaving a backlog of work on April 30 of 2,687,256 tons.

June 4

▲ May shipments of iron ore from U. S. and Canadian ports down the Great Lakes were reported at 12,553,857 gross tons by the Lake Superior Iron Ore Association. Total shipments in May, 1955 were 11,605,757 gross tons.

▲ Installment credit outstanding at April 30, 1956 totaled $28,300,000,000 or $4,800,000,000 above a year ago.

▲ The AISI reports that the operating rate of the steel industry for the week of June 4 is scheduled at 96.4 per cent of capacity. This is equivalent to 2,373,000 tons compared with 2,370,000 tons one week ago and 2,286,000 tons one year ago. Index of production for the week is 147.7.

▲ The AISI reports estimated payroll for the iron and steel industry for April, 1956 at $326,740.00. Average hourly payroll cost of wage earners was $2.621 for each hour worked during April compared with $2.604 in March. In addition to the above, the hourly cost for pensions, social security, and insurance amounted to 21.3¢ per hour. Working hours averaged 39.7 hr per week in April compared with 40.7 hr per week in March. Estimated number on payroll was 687,900.

June 6

▲ The Commerce Department reports that personal income in April rose to an annual rate of $317,000,000,000 or $2,000,000,000 above the March pace.

▲ Lone Star Steel Co. announced that the RFC had approved a new financing plan which may enable the company to refund its $77,700,000 debt without issuing additional stock.

June 7

▲ An agreement was reached between Bethlehem Steel and the USW under which the company would adjust its incentive pay plan. The company reported that the pact called for conversion over a period of time of all its incentive plans to a standard hourly wage rate basis, to conform with the general method used by the steel industry. This agreement is separate from the current negotiations on the new labor contract.

June 8

▲ Commerce Secretary Weeks announced that companies expanding plant and equipment facilities plan to step up such expenditures to yearly rates of $36,700,000,000 in the third quarter, an increase of $1,900,000,000 over the rate scheduled for the quarter ending June 30th.

▲ AISI reports that shipments of finished steel products from steel mills during April, 1956 were 7,783,873 net tons, second highest monthly total.

▲ Kaiser Steel Corp.'s net earnings for the nine-month fiscal period ended March 31, 1956 were $7,226,000, equal to $1.73 per share of common stock. Net sales for the same period amounted to $123,848,000, 40 per cent over the sales of $88,346,000 for the same period last year.

▲ Consumption of scrap and pig iron during April totaled 12,551,000 gross tons a decrease of 4 per cent from March, according to the Bureau of Mines, U. S. Department of the Interior. Of this, scrap consumed in April totaled 6,377,000 tons.

June 11

▲ The AISI reports that the operating rate of the steel industry for the week of June 11 is scheduled at 96.6 per cent of capacity. This is equivalent to 2,378,000 tons compared with 2,380,000 tons one week ago, and 2,316,000 tons one year ago. Index of production for the week is 148.0.

▲ The Office of Defense Mobilization granted fast tax write-offs on proposed expenditures totaling $542,800,000 for diesel locomotives and freight cars.

June 12

▲ William C. Stalk, president of the American Can Co., announced that the company will spend $27,000,000 on facilities to process plate from continuous strip. The company will buy coils and process them in its own plant in a move to combat rising tin and steel plate prices.

June 13

▲ Government figures showed that expenditures for construction of all types in May exceeded April by 9 per cent bringing the total for the year, to date, to $15,800,000,000 an increase of $200,000,000 over the same period in 1955. Contracts for future homes construction, according to the F. W. Dodge Corp. reports, in the 37 states east of the Rockies, rose to $1,100,000,000 in May, exceeding last May by 12 per cent.

▲ Cement prices were increased 10 cents a barrel for the third quarter in various locations in the midwest and south by the Lone Star Cement Co. and the Penn-Dixie Cement Co.

June 14

▲ A new $50,000,000 corporation called American Coal Shipping, Inc., has been formed by coal miners and producers with coal carrying railroads in an effort to broaden exports of the fuel. The corporation plans to obtain ships to carry coal to Europe and thus convey coal across the ocean at a cost low enough to hold the market.

▲ Proposals were submitted by the U. S., Bethlehem and Republic Steel Corps. to the USW offering pay increases, guaranteed annual wage, and other concessions, countering demands of much broader scope presented by the USW.

June 15

▲ The Bureau of Statistics reported that Canadian output of pig iron in April, 1956 totaled 287,083 tons compared with 272,187 tons last year, steel ingot output rose to 423,614 tons compared with 353,377 in April, 1955.

▲ Electro Metallurgical Co. announced price increases of from ¾¢ to 3¢ on various grades of its chromium alloys and calcium-silicon products, effective immediately on a spot basis and effective July 1 on all shipments to contract users.

June 18

▲ David J. MacDonald, president of the USW, ridiculed the proposals submitted by the three major steel companies and announced negotiations would be undertaken individually with 11 major steel companies. Failure to "get anywhere" in talks with the big three was cited as the cause of the change in plans.

▲ The AISI reports that the operating rate of the steel industry for the week of June 18 is scheduled at 95.7 per cent of capacity. This is equivalent to 2,355,000 tons compared with 2,299,000 tons one week ago and 2,292,000 tons one year ago. Index of production for the week is 146.6.

▲ The U. S. Dept. of Commerce announced that shipments of gray iron castings during March, 1956 amounted to 1,255,000 short tons, approximately 3 per cent above February, 1956 but 5 per cent below the March, 1955 level. Steel castings shipments totaled 170,000 tons in March, 3 per cent above February shipments and 33 per cent above the March, 1955 shipments.

June 19

▲ The Aluminum Assn. reported primary production of aluminum during May totaled 301,600,064 lb in comparison with 289,452,612 lb in April, 1956 and 262,256,314 lb in May, 1955.

▲ Deliveries of new domestic freight cars in May showed an increase to 6667 from 5943 in April, and 4083 in May, 1955. Orders in May totaled 2403 compared with 6559 in April. Backlog of cars on order as of June 1 stood at 133,072 cars.

▲ An advance report of the 1954 Census of Manufacturers released by the Bureau of Census, states that during 1954, gray-iron foundries shipped products valued at $1,418,733,000 and increase of 21 per cent over the 1947 total. Average employment dropped 23 per cent to a total of 133,884 employees in 1954.

▲ An offer of financial relief was offered its 12,000 strike-idled steelworkers of the Tennessee Coal & Iron division of the U. S. Steel Corp., by advance vacation pay of $2,100,000. The 51-day-old shutdown has resulted in about 25,000 jobless employees in the plant, with approximate reduction in steel production of 550,000 tons.

▲ Youngstown Sheet and Tube Co., Campbell Works, open hearth workers yesterday ended a 4-day wildcat strike over pay incentive rates.

June 20

▲ F. W. Seibert, director of one of West Germany's biggest steel companies, predicts West Germany's purchases of coal in the U. S. in 1956 will rise to 42,000,000 tons, compared with 27,000,000 tons in 1955.

June 21

▲ The Industrial Heating Equipment Assn. reported that orders received for industrial furnaces during May amounted to $3,620,221, down 42 per cent from May, 1955. Orders for the first five months of 1956 topped the like period in 1955 by 32 per cent.

▲ The Labor and Commerce Departments announced expected construction outlays this year will top 1955 by 4 per cent despite a 12 per cent decline in private housing. The upward forecast resulted from stepped-up construction of industrial plants and highways. The estimates for 1956 for all types of building were advanced to a record $44,500,000,000 compared with actual expenditures in 1955 of $43,000,000,000.

▲ An attempt to break the steel industry's solid front was abandoned by the USW and they announced that separate conference with the 11 companies was halted and joint negotiations resumed with the U. S., Bethlehem and Republic Steel Corps.

▲ April 1956 shipments of gray iron castings amounted to 1,218,000 short tons, 3 per cent below March, 1956 and 6 per cent below April, 1955; malleable iron castings were 83,000 tons, steel castings shipments were 164,000 tons.

June 22

▲ The Commerce Department clamped an embargo on exports of all nickel bearing scrap materials for the third quarter.

June 25

▲ The AISI reports that the operating rate of the steel industry for the week of June 25 is scheduled at 94.0 per cent of capacity. This is equivalent to 2,314,000 tons compared with 2,290,000 tons one week ago and 1,716,000 tons one year ago. Index of production for the week is 144.1.

▲ Copper prices were cut 2.3¢ a lb by Union Miniere to 38.10¢ in New York, making its quotation close to the 37½¢ level established recently by Northern Rhodesian mines.

▲ New orders in May for machine tools rose to $93,600,000, 10 per cent above April, 1956 and 30 per cent over May, 1955.

▲ The Commerce Department reported that the average before-tax family income amounted to $5520 in 1955, an increase of 3 per cent over 1954.

June 26

▲ United States aluminum producers plan to increase their production capacity more than one-third by 1958, to 2,300,000 tons annually compared with 1,600,000 tons in 1956.

June 27

▲ A bill providing for a $33,000,000,000 road-building program and accompanying increases in federal taxes on gasoline, tires and trucks was adopted by Congress.

▲ The Bureau of Labor Statistics reported that living costs in May increased 0.4 per cent over April, 1956, and the Government consumer price index rose to 115.4 per cent of the 1947-49 average.

June 28

▲ The five founder engineering organizations received a recommendation from a task committee that the societies headquarters remain in New York. This decision is considered final and shuts out Pittsburgh as a possible headquarters location.

▲ The Interlake Iron Corp. announced that its stockholders, at a special meeting in New York, approved the proposal to acquire the assets of the Globe Iron Co. of Jackson, Ohio in exchange for shares of Interlake Iron stock and in addition to offer to exchange Interlake stock for the publicly held shares of Globe Metallurgical Corp. of Beverly, Ohio.

June 29

▲ Jones & Laughlin Steel Corp. is planning a large, integrated, 1,000,000-ton steel mill near Houston, Texas at an estimated cost of $300,000,000. Finished product primarily will be pipe for oil industry.

▲ Inland Steel Co. will offer $50,000,000, of first mortgage bonds in late July to help finance its capital expenditures of $260,000,000 for increasing its steel-making capacity by the end of 1958 as well as additions to the company's finishing facilities.

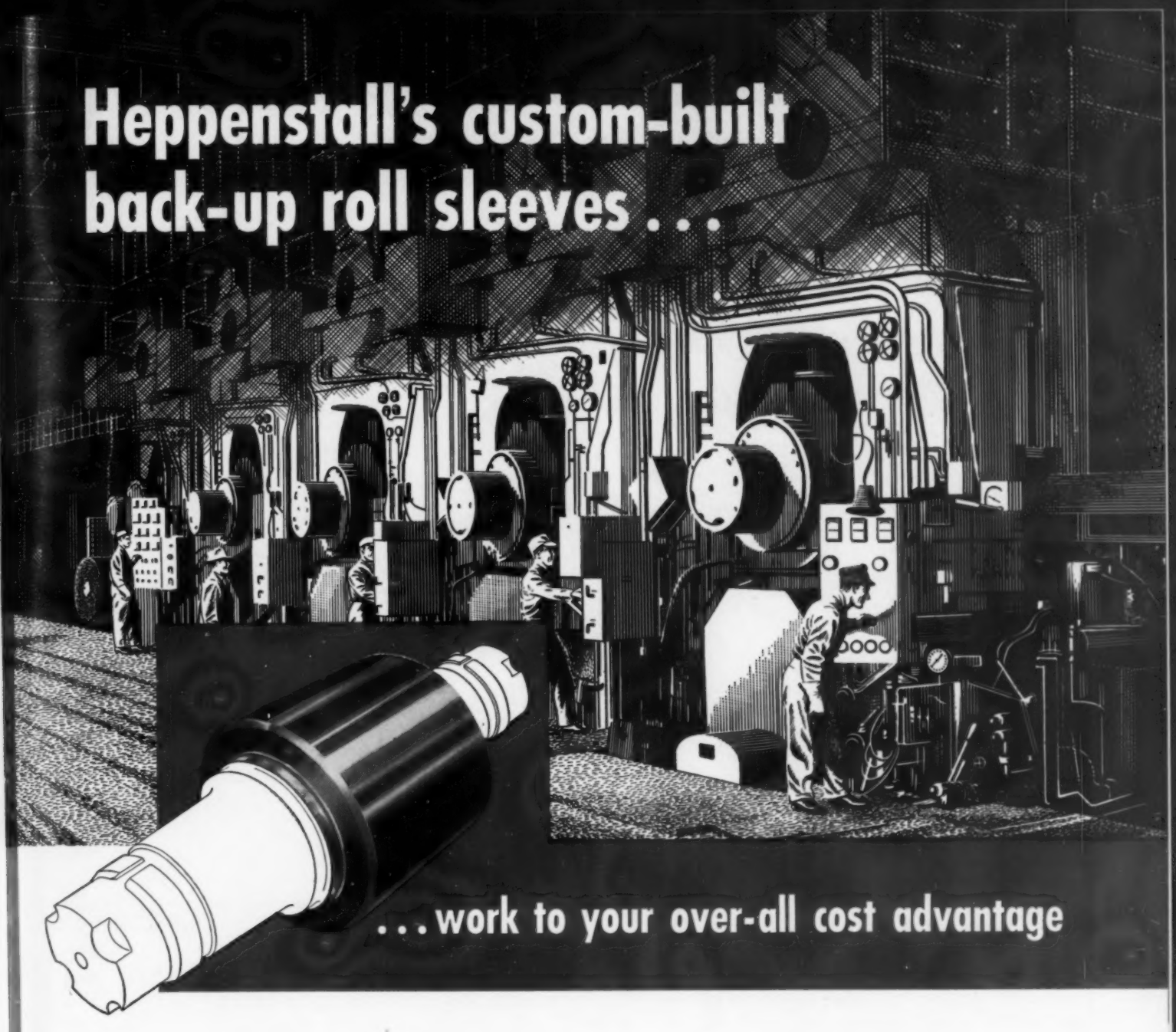
▲ Imports to United States climbed to $1,084,000,000 during May, 1956, an increase of $94,000,000 over April, 1956 and $126,000,000 over May, 1955.

June 30

▲ DuPont Co. announced a reduction of 25¢ per pound in the price of the titanium sponge and Grade A-1 sponge will now cost $3 a pound. DuPont also announced plans to double capacities of the Newport, Delaware plant by 1958.

▲ The United Steel Workers of America, CIO, went out on strike at midnight today, shutting down operations in the majority of steel plants in the United States with a few exceptions.

Heppenstall's custom-built back-up roll sleeves . . .



. . . work to your over-all cost advantage

Heppenstall Back-Up Roll Sleeves enable you to roll record tonnages . . . decrease downtime . . . and effect over-all cost reduction. They give longer working life in today's high-speed mills because their up-to-the-minute design permits utilization of more effective forging and heat treating operations in their production. Each sleeve's working surface is *tempered to meet your exact hardness specification.*

These mandrel-forged sleeves—made from highest quality Heppenstall-produced alloy steel—are worked thoroughly under modern hydraulic presses to produce a finished product having both maximum density and grain refinement. In addition, they offer you exactness of fit and greater resistance to cracking and spalling during high-speed rolling.

All Heppenstall sleeves are fitted to extremely close tolerances which prevent circumferential slippage. Longitudinal movement is also eliminated because they are further locked in place by both a shoulder and Heppenstall's own patented locking ring.

Heppenstall also produces forged arbors . . . has facilities to grind both arbors and sleeves for perfect shrink-fitting.

For additional information and technical assistance, contact Heppenstall Co., Pittsburgh 1, Pennsylvania. Sales offices are located in principal cities.

Heppenstall

The most dependable name in forgings

Strand Annealers

30-KW Drever 12 tube furnace with 9 foot heating chamber. Capacity 85 lbs./hour (.020" wire); speed 50 to 200 feet per minute.

FOR

Bright Annealing

STAINLESS WIRE

Clean Bright high quality stainless or alloy wire is heat treated economically in Drever Continuous Bright Annealing Furnaces.

Versatility of production is possible by design of pay-off and recoiling mechanisms. Each block is driven individually, thus wire of different diameters may be annealed at varying speeds at the same time.

Proper atmosphere equipment is supplied depending on type of wire to be bright annealed.

Write for further details on this or other type of Drever Furnaces.

DREVER COMPANY

BETHAYRES, PA.

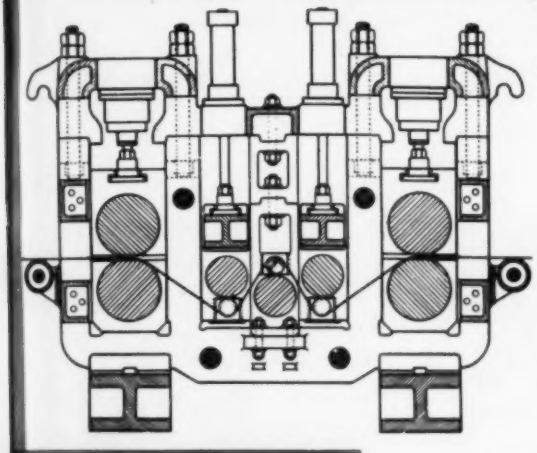
F&Y TRIPLE SCALE BREAKER

Speeds Pickling with the New

"YOUNGSTOWN"

High Speed Continuous Strip Pickling Line

...Better Pickling with Less Acid and Lower Cost!



See our new, pull thru type, TRIPLE SCALE BREAKER, —a revolutionary improvement that eliminates the need for a Pinch Roll Stand in a modern Pickling Line. Investigate this and other new "YF&M" advantages. Whatever your pickling requirements,—complete new lines, revamping of existing lines, new tanks, rubber-covered rolls, Paralloy pinch rolls, any pickling line equipment,—get the benefit of our 70 years' experience. Consult "Youngstown" on how to speed up your pickling, cut acid consumption and make your operation more profitable.

features—

- Cone Type Payoff with Strip Opener.
- Triple Processor with Roller Leveller.
- Flash Welding and Mechanical Stitching.
- Pull-Thru Type Triple Scale Breaker.
- Single Cycle Up-Cut Shears.
- Heavy Duty Rubber Covered, Brick Lined Steel Tanks.
- Magnetic Loop Control for Acid Tanks.
- Fume Exhaust System —Roto Clone Scrubber.
- Automatic Control for Temperature and Acid Proportioning.
- Side Trimmer with Scrap Cutting or Balling
- Up-Coiler with Strip Oiling System.
- Entry and Exit Coil Conveyors

F&Y

The Youngstown Foundry & Machine Co.

SERVING INDUSTRY SINCE 1885

Youngstown, Ohio

GENERAL ELECTRIC *Control*

For fast, accurate performance, low operating costs, specify General Electric d-c control for your crane

If you're looking for the ultimate in crane control—from high-speed lowering to pin-point spotting, you want General Electric d-c crane control!

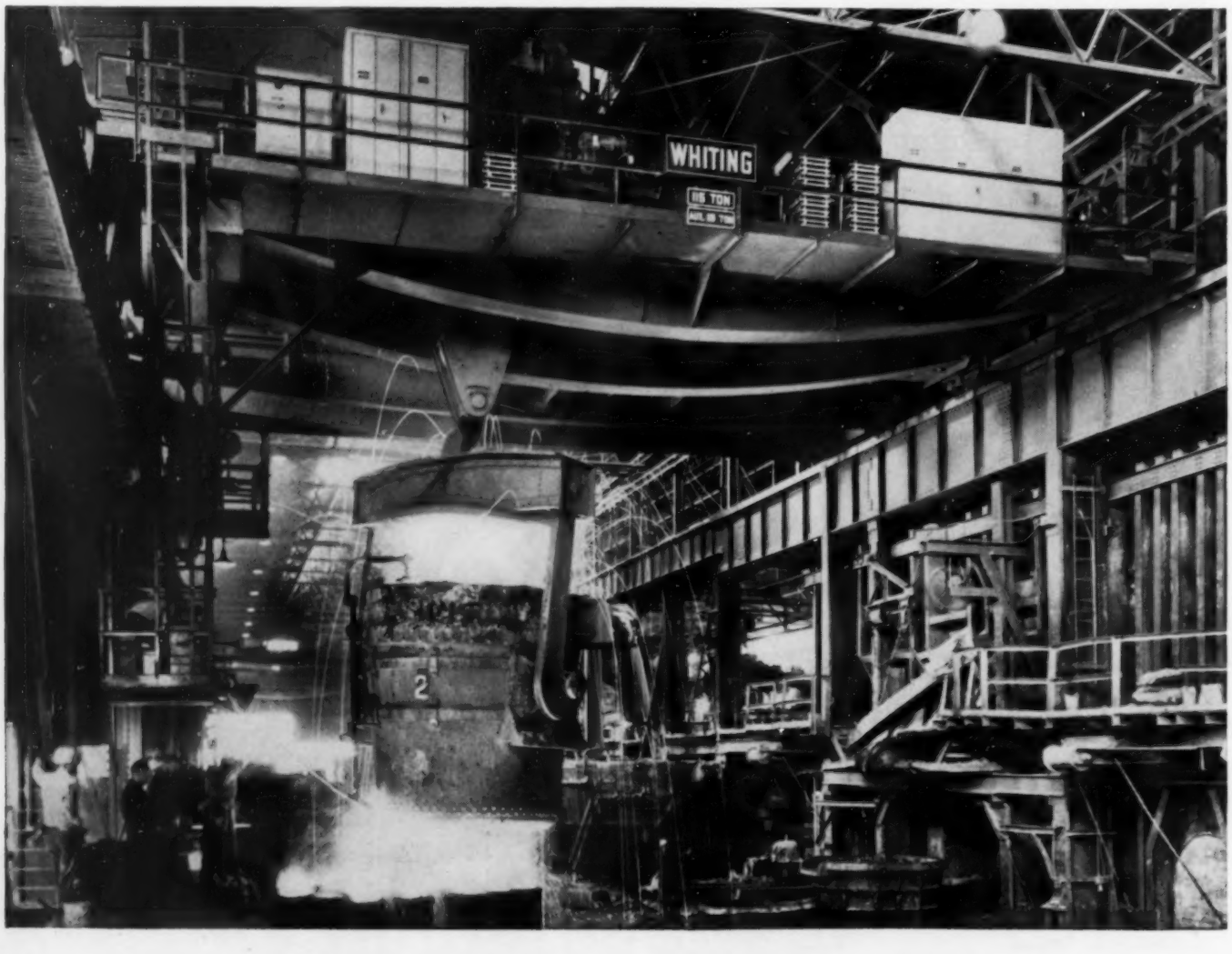
In designing the complete electrical system of your crane, G-E engineers work closely with your crane manufacturer to assure completely co-ordinated equipment. This integration of all mechanical and electrical components assures you of top crane operation, minimum downtime, and lower over-all operating costs. And because G.E. has a complete line of crane controls you are certain to get performance tailored to your specific operation.

ACCURATE HOIST CONTROL for every speed and load is assured with G-E d-c drives. Operational features, such as, five distinct speed points, dynamic braking, automatic acceleration and deceleration, and non-cycling operation provide you with a fast, efficient system.

PRECISION BRIDGE AND TROLLEY CONTROLS offer automatic acceleration, smooth reversal of motion without motor overload, and built-in automatic protection against motor overloading.

MINIMUM REPLACEMENT is required with General Electric d-c crane control. Each control component is tested under severe operating conditions and proved for the job before delivery.

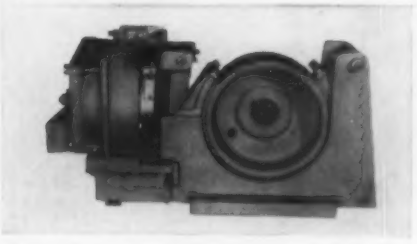
TAKE ADVANTAGE of these benefits by specifying G-E control for your next crane. Your G-E sales engineer will be happy to work with you and your crane manufacturer to engineer the right drive system. Industry Control Dept., General Electric Co., Roanoke, Va.



News for the steel industry

These G-E control products have top features for steel mill use:

DC BRAKES



SINGLE POINT ADJUSTMENT—only one adjustment is needed to regulate lining wear on both brake shoes.

REMOVABLE LININGS—linings can be replaced in minutes, without removing the entire shoe assembly.

ARMATURE GAP INDICATOR—easily visible indicator shows when to adjust for lining wear.

MANUAL RELEASE—a simple and convenient method is provided for manually releasing the brake.

DRUM SWITCHES

DOUBLED CONTACT LIFE—each contact is reversible and may be turned to receive wear on each side, thereby reducing replacement costs.

FAST EASY INSTALLATION—conduit boxes have knockouts in bottom, sides, and back to simplify installation.

REDUCED MAINTENANCE TIME—easily removable covers allow complete access to all working parts.

INTERCHANGEABLE MECHANISMS—standard horizontal handle may be replaced by rope wheel, vertical handle, or switchboard mechanism.

LIMIT SWITCHES

HEAVY DUTY CONSTRUCTION—able to stand up under punishment of severe shock, vibration, moisture, and dust conditions.

REDUCED MAINTENANCE—there are no shunts or drum-type segments to replace or maintain.

LONG LIFE—each double-break, silver contact is independently adjustable for opening and closing.

SIMPLE TO CONNECT AND ADJUST—cover is easily removed to allow access to terminals plus ample wiring space for conduit connection.

MASTER SWITCHES

RUGGED CONSTRUCTION—cast-aluminum cover protects cams and contacts from dirt and dust and accidental rough handling.

FLEXIBLE—may be used with reversing or non-reversing controllers and is available with up to 12 circuits.

EASILY REMOVABLE CONTACTS—the stationary and movable contacts may be removed easily without disturbing the wiring.

POSITIVE MAKE OR BREAK—design of contact mechanism assures positive make or break.

For more information on any of these control products write Section 784-4, General Electric Co., 1 River Rd., Schenectady 5, N. Y.

GENERAL ELECTRIC

TORRINGTON BEARINGS

Heat treating makes the difference!

At Torrington we're as fussy with heat treating a bearing as an expert chef is about a charcoal-broiled tenderloin. No wonder TORRINGTON BEARINGS last long and give dependable service wherever they are used.

For out of TORRINGTON's advanced heat-treating facilities come races and rollers that are consistently hard . . . stable . . . uniform. Quality of steel is important and that's carefully controlled, too. Only the finest bearing quality steels—case-hardening or through-hardening grades—are used in manufacture.

At the Bantam Bearings Division, we make all types of bearings for heavy duty application—Spherical Roller, Tapered and Cylindrical Roller, Heavy Duty Needle, Ball and various types of thrust bearings.

Make sure you specify TORRINGTON. Our many basic types of anti-friction bearings are backed by custom engineering to meet your speed and load requirements. For special jobs, your TORRINGTON engineer will be happy to select or help design the best bearing for you. Call him today!

THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.
District offices and distributors in principal cities of United States and Canada

90th ANNIVERSARY 1865–1955

TORRINGTON BEARINGS

Spherical Roller • Tapered Roller • Cylindrical Roller
Needle • Ball • Needle Rollers

SCHLOEMANN

Pressing Force 3,000 tons
Stroke of Ram 21½ in.
Strokes/min. 6
Length of Table 33 ft.
Width of Table 6 ft.
Height above floor 23½ ft.

Mechanical toggle lever press for automobile- and airplane construction

for punching, perforating and bending of heavy beams as well as for drawing of plates and sheets. Its vast field of application and its special equipment make this press an exceptionally economical operating machine; this has been proved by years of successful operation.

Existing Equipment by SCHLOEMANN

Domestic users of equipment built by Schloemann are assured of competent service - engineering, supply of genuine spare, and repair parts. Call a Feller service engineer.

FELLER ENGINEERING COMPANY
1159 Empire Building, Pittsburgh 22, Pa.
Exclusive U.S. Agent

Ohio Rolls

Chemically Correct Metallurgically Sound

Through the entire complex and exacting process of manufacturing OHIO ROLLS, Ohio's metallurgists, chemists, engineers and inspectors are continually analyzing, testing and inspecting. Their job is to make sure that every Ohio Roll meets exact specifications for metal analysis, hardness, tensile strength, dimension and finish. Ohio's quality control techniques and casting skills are your best assurance that Ohio Rolls deliver higher tonnage . . . give longer, more profitable service under critical operating conditions.

When you need rolls—large or small—call in your Ohio Roll Representative. He understands production requirements, and he can help you solve your roll problems quickly and efficiently.

OHIO ROLLS SERVE THE WORLD

shaping metal for all industry

Carbon Steel Rolls • Ohioloy Rolls • Ohioloy "K" Rolls • Ohio Double-Pour Rolls
Chilled Iron Rolls Dense Iron Rolls • Nickel Grain Rolls • Special Iron Rolls
Nioloy Rolls • Flintuff Rolls • Forged Steel Rolls

THE OHIO STEEL FOUNDRY COMPANY

LIMA, OHIO **Plants at Lima and Springfield, Ohio**

Industry News...

ADDITIONAL COKE OVEN BATTERIES BEING REBUILT AT CLAIRTON WORKS OF U. S. STEEL

▲ Three old batteries of coke ovens at U. S. Steel Corp.'s Clairton Works are being torn down for complete rebuilding as part of the continuing modernization of the coke plant's 23 batteries.

Wilputte Coke Oven Division of the Allied Chemical and Dye Corp. has the contract for construction work and will erect the batteries on the site of old Nos. 10, 11 and 12 batteries now being demolished.

There will be 192 new ovens measuring 37 ft long, 12 ft high and 19 in. wide. Of the gun-flue type, the batteries have double collector mains for gas and coal chemical recovery. Equipped with self-sealing doors and the most modern design for smoke elimination, the ovens will be served by a new quenching station and screening facilities.

The coke oven rebuilding program at Clairton began shortly after World War II, and by the fall of 1955 a total of 16 batteries had been rebuilt with one entirely new battery added. The rebuilding of Nos. 10, 11 and 12 batteries is a continuation of that program and, when completed, will leave only three old batteries still to be rebuilt.

Clairton has a total of 23 batteries in which more than 30,000 tons of coal are charged daily.

ARMCO TO ADD SINTERING PLANT AT ASHLAND, KY.

▲ A new Dravo-Lurgi iron ore sintering plant will be installed at the Ashland, Ky., works of Armco Steel Corp. Contract for constructing the new sintering plant has been awarded by Armco to Dravo Corp. Along with the complete sinter plant, Dravo will install a Walker Process flue dust thickener.

The sinter machine, approximately 150 ft long, will have an output capacity of some 2400 tons per day.

The new plant is expected to be completed in the latter part of 1957.

BREAK GROUND FOR OXYGEN CONVERTER PLANT

Ground breaking for the West Coast's first oxygen converter plant is witnessed by B. N. Dagan (left), works manager, Kaiser Steel Corp. and E. T. Larsen, vice president-engineering, Kaiser Engineers. Installation of the oxygen converter plant at Fontana, Calif., is part of Kaiser Steel's new $113,000,000 expansion program, designed to boost its annual steel production by approximately 40 per cent. Kaiser Engineers has been awarded the contract for the over-all expansion program, design, engineering and construction.

SLABBING MILL CONTRACT IS AWARDED TO UNITED

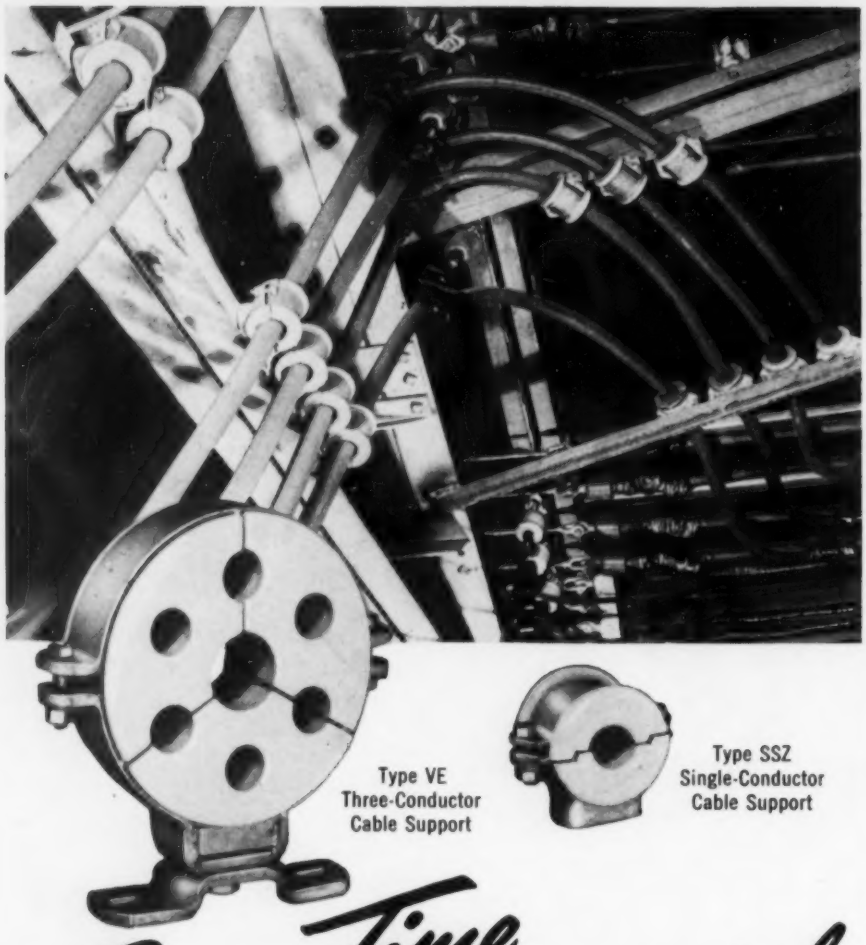
▲ Inland Steel Co. has placed an order with United Engineering and Foundry Co. for a new universal slabbing mill. The mill is a part of the company's $260,000,000 expansion program announced eight months ago which includes a 15 per cent increase in steelmaking capacity for its Indiana Harbor Works in East Chicago, Ind., from 5,200,000 to 6,000,000 ingot tons annually.

The new mill will handle 1,800,000 tons of steel annually, or more than twice the contemplated increase in ingot capacity. Furthermore, it will be so designed that it can subsequently be equipped to roll 4,750,000 tons of ingots annually, almost double the slabbing capacity of the plant's three present mills.

WESTINGHOUSE EXPANDS AT EAST PITTSBURGH

▲ Manufacturing facilities at the East Pittsburgh plant of the Westinghouse Electric Corp. will be expanded and improved this year in a program costing well over $1,000,000. The expansion plans were announced recently by L. B. McCully, vice president and manager of the firm's East Pittsburgh Divisions.

The expansion will be made in the plant's transportation and generator division and will be handled as two projects. One project—already under way—consists of installing new equipment and rearranging facilities to meet demands from steel mill customers. The second project, currently in its final planning stage, will provide additional capacity for the pro-



Save Time and Material

with open wiring and Delta-Star clamp-type cable supports

This flexible, high-voltage system is installed quickly with reduced handling and material costs. Open wiring permits cables to be worked at higher current densities. Extensions, taps and rearrangements are easily made.

Delta-Star cable supports are available in two types: *Type VE* three-conductor cable supports have all conductors within the same clamp. Close triangular spacing balances the circuit and minimizes reactance to reduce voltage drops over long distances. Permits multiple circuits of same size conductors. Occupies minimum space.

Type SSZ single conductor cable supports are available with adapter plates for group mounting two, three or four supports.

All Delta-Star cable supports may be mounted on pipes, beams and other flat surfaces.

For detailed information, write for publication 4210-A—or see your Delta-Star representative.

HKP DELTA-STAR ELECTRIC DIVISION
H. K. PORTER COMPANY, INC.
2437 Fulton Street · Chicago 12, Illinois · District offices in principal cities

duction of large generators for electric utilities.

Discussing the steel mill equipment project, Mr. McCully said that the largest lathe ever to be installed in the East Pittsburgh plant is now being readied for operation. In addition, a new railroad spur track for shipping purposes, a 50-ton crane, modernized lighting facilities, and increased manufacturing and test space will be provided.

The larger of the two projects, which is planned for the near future, will be the expansion of facilities in the plant's "D" Aisle where large generators are assembled and tested. Additional motor-generator sets will be installed to provide increased testing power, and assembly and test facilities will be expanded and rearranged for more efficient operation.

FURNACE COMPANY HEAD TOURS SOVIET PLANTS

▲ Lee Wilson, chairman of the board of the Lee Wilson Engineering Co., Inc., is making a tour of the major steelmaking operations in Russia.

Mr. Wilson will study Russian methods at both the big Ukraine centers at Dnieper and Donetz and the Trans-Caucasian mills in southern Georgia. He also has requested permission to visit the newer facilities at Magnitorsk in the west. His plans also include a tour of the Kremlin.

Upon his return, Mr. Wilson will release a comprehensive report on Russian annealing practice in steelmaking.

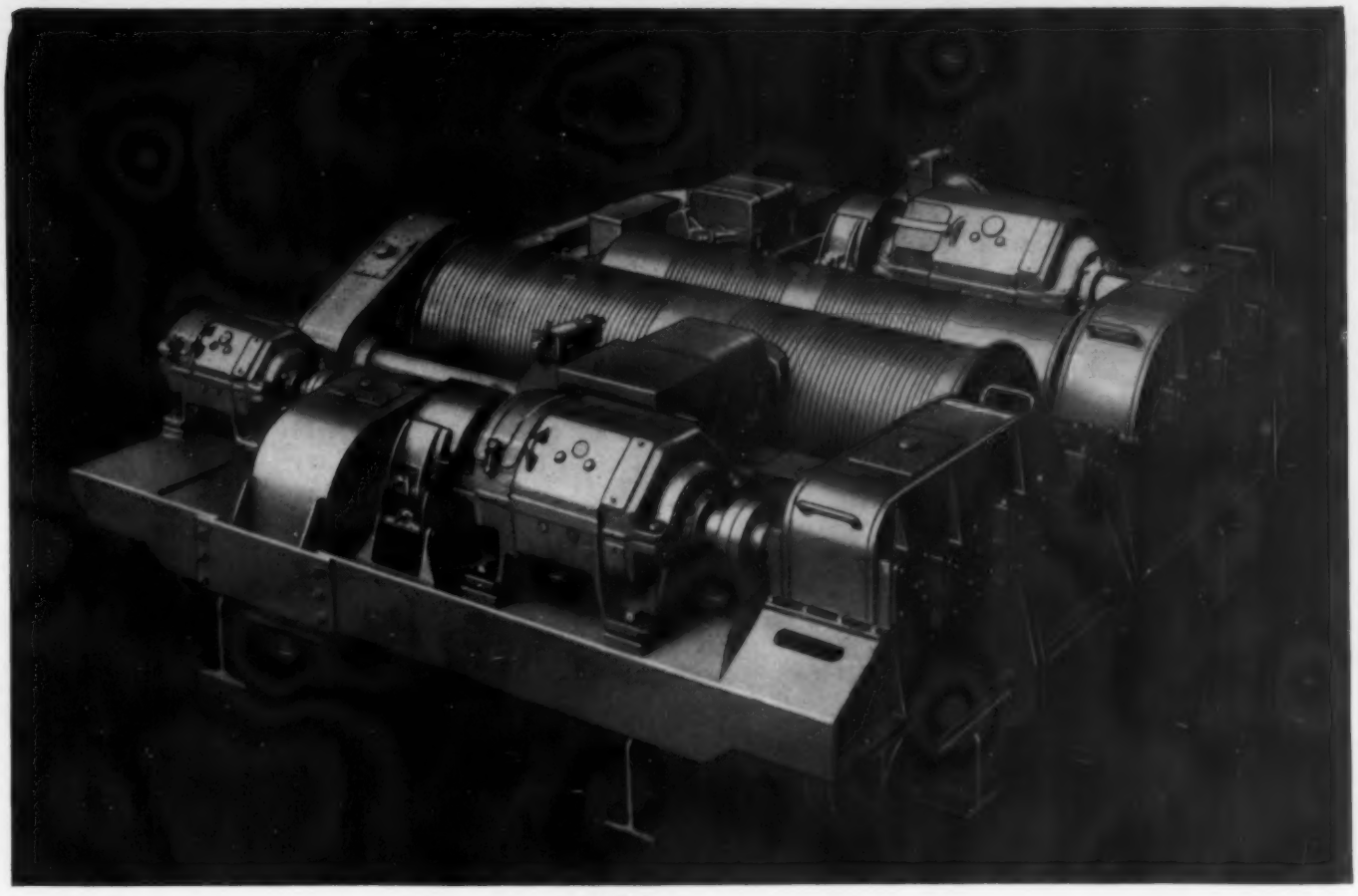
YORK-GILLESPIE NAMES SALES REPRESENTATIVE

▲ The appointment of the W. P. Woolridge Co. as their exclusive western sales representatives has been announced by the York-Gillespie Manufacturing Co.

Woolridge main offices are in Burlingame, Calif. Branch offices are maintained at Los Angeles and Salt Lake City, Utah.

LOFTUS TO CONSTRUCT FURNACE FOR REM-CRU

▲ A furnace contract has been awarded by Rem-Cru Titanium, Inc. to Loftus Engineering Corp. This furnace is natural gas fired and is a continuous double row, walking beam type.



VICTOR R. BROWNING *Trolleys*

FOR HEAVY DUTY MILL TYPE CRANES

"Simple Design is Sound Design"

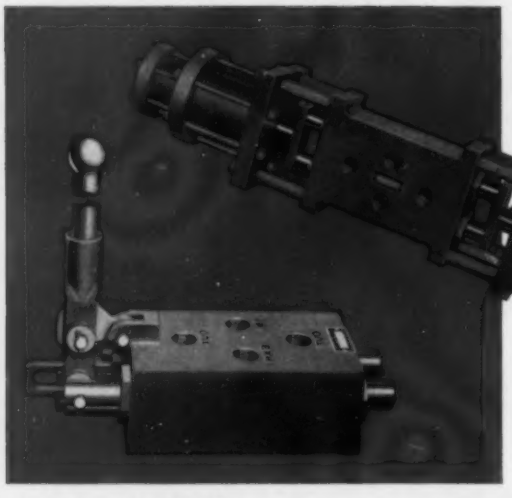
We offer a complete line of trolleys built to meet the most exacting requirements. These trolleys are constructed of the finest materials available. No cast iron is used. All shafts are of highest quality alloy steel. All bearings are calculated with a proper life factor for service required as defined by the A.I.S.E. We will build a trolley to fit your special requirements as to gauge, head room, approaches and general arrangement. We also make a complete line of cranes for steel mill use. . . Your inquiries will be welcome.

VICTOR R. BROWNING & COMPANY, Inc.

BOX 309, WILLOUGHBY (CLEVELAND), OHIO

Designers and Builders of Electric Overhead Traveling Cranes and Hoists and Electric Revolving Cranes

Quick-As-Wink® HYDRAULIC VALVES



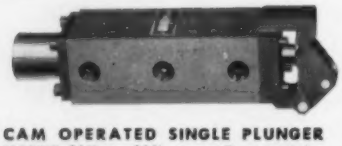
Double Pilot Cylinder Operated 3-position 4-way Hydraulic Valve

(At left) Lever Operated 3-position 4-way Hydraulic Valve

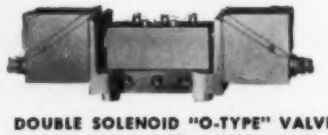
Hand and Pilot-operated Types for water or hydraulic oils to 5000 psi.

• These valves give users maximum efficiency, economy and dependability. Housings are milled from steel blocks or bronze forgings. The hollow, radially ported, stainless steel plungers are hard chrome plated and polished. Renewable metal valving rings assure long life of the packers which are expanded by internal pressure . . . the higher the pressure the tighter the seal. No metal to metal seating. The valves are fully balanced in any position. Inspection — and servicing if necessary — can be done easily *in the field,* avoiding the delays of returning valves to the factory for servicing, or the need to carry large inventories of standby valves — or even parts. Complete dimensions, capacities and other data sent promptly. Write for Bulletin No. 531,— Today!

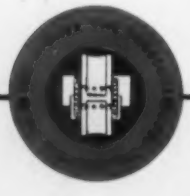
Ask us also about . . .



CAM OPERATED SINGLE PLUNGER VALVE ⅜" to ¾" sizes. Operated by rotating cam or land on reciprocating device.



DOUBLE SOLENOID "O-TYPE" VALVE for pressures up to 125 psi. Widely used as pilot valves and for operating air cylinders.



Quick-As-Wink® AIR AND HYDRAULIC Control Valves

Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

Mfd. by C. B. HUNT & SON, INC., 1921 East Pershing St., Salem, Ohio

It will be installed at Crucible Steel Co. of America's Park Works. Crucible and Remington Arms Co. Inc., are joint owners of Rem-Cru. The furnace will be used to heat titanium to rolling temperature.

Loftus will design and engineer the furnace, as well as furnish all materials and erection labor to build the furnace. Crucible will construct the foundations.

TO BUILD LADLE CRANES FOR SPARROWS POINT

▲ Three 500-ton pouring or pit side ladle cranes, the largest ever built, have been ordered from the Morgan Engineering Co. for Sparrows Point Plant of Bethlehem Steel Corp.

These cranes are part of a group being furnished by Morgan for an extensive open hearth and slabbing mill expansion program. They will operate in a new open hearth shop, servicing seven large open hearth furnaces.

DRAVO BUILDS SINTERING PLANTS FOR U. S. STEEL

▲ Two giant iron ore sintering plants—one at Gary, Ind., and the other at Saxonburg, Pa.—are being built for United States Steel by Dravo Corp.

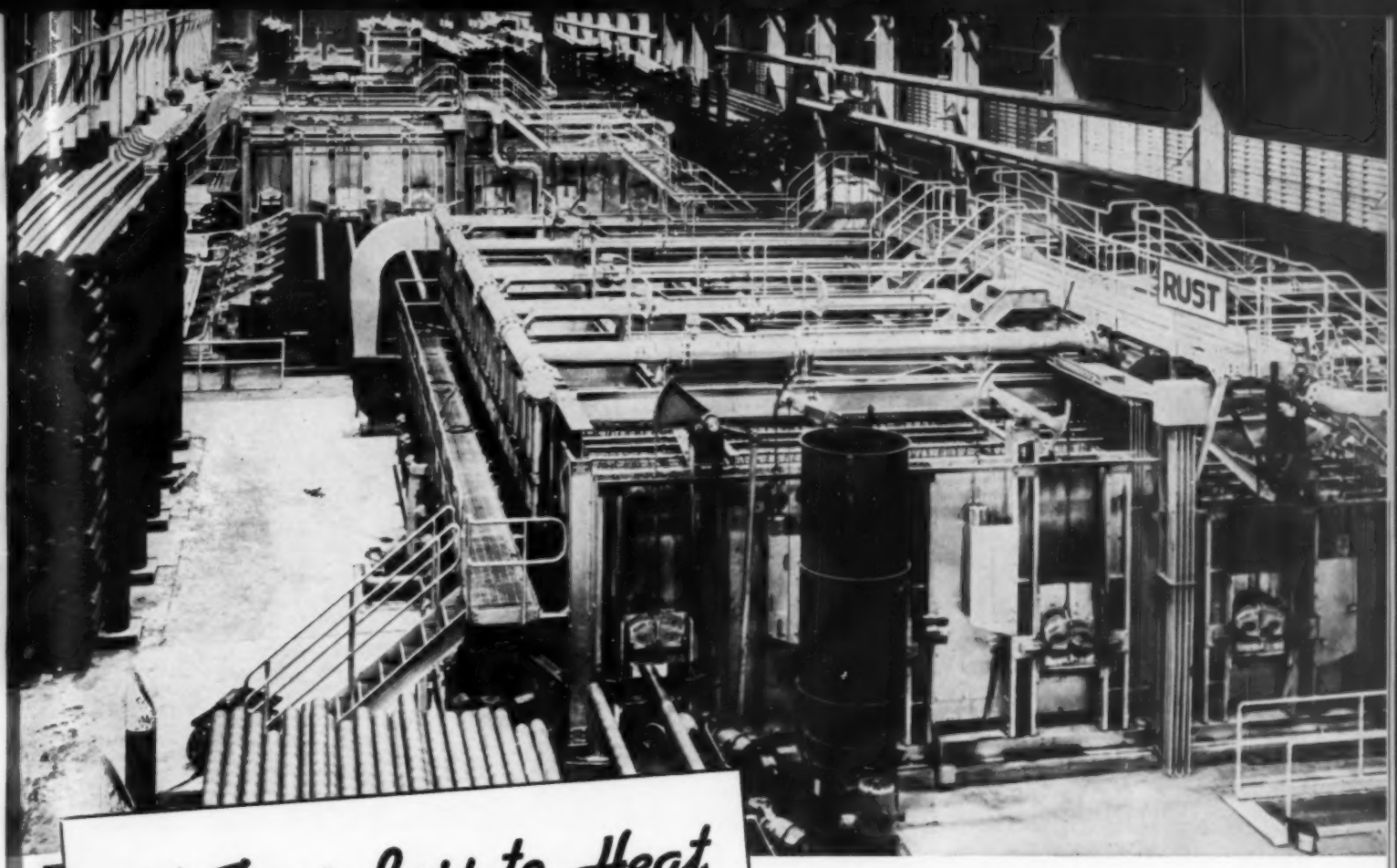
The sintering plants were designed in collaboration with, and under license by, the Lurgi Co. of Frankfurt, Germany.

Initial capacity of each sintering plant will be in excess of 15,000 tons of iron ore sinter per day. Each plant will contain three machines and provisions are included for adding a fourth at a later date.

The sintering plant at Gary will process iron ore from U. S. Steel's properties in the Mesabi Range of Minn. The second plant at Saxonburg, just north of Pittsburgh, will process iron ore shipped from Mesabi and from U. S. Steel's new mines in Venezuela.

Each sintering machine will be eight ft three in. wide, 200 ft long and about 50 ft high.

In connection with each sintering plant, there also will be a building to house the raw matrials, mixing and storage bins. The material will move on conveyor belts from this building to sintering machine charging hoppers.



116 Tons Less to Heat in this roof

because of B&W Insulating Firebrick suspended construction

Here's another case where light weight means lower cost. The roof of this walking beam furnace is 2,320 square feet. B&W Insulating Firebrick suspended construction for a 9-inch roof weighs about 30 lbs per square foot, including the weight of rods, hangers, pipe, brick and mortar. This is approximately 100 lbs per square foot less than an arch constructed of heavy firebrick plus insulation having the same heat flow. *This saving means the B&W IFB roof is 116 tons lighter.*

The new walking beam furnace (shown in photograph above) was designed and constructed by Rust Furnace Company for Jones & Laughlin Steel Corporation. Seamless pipe is conveyed into the furnace, moves slowly from left to right on walking beam rails designed and furnished by York-Gillespie Mfg. Co., and passes out the exit door.

Here are the money-saving benefits of B&W suspended construction:

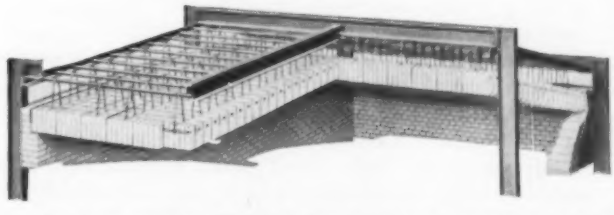
1. Supporting steel is less massive, far less costly. Commercial size steel can be used for roof suspension instead of special castings.

2. B&W Insulating Firebrick heat up and cool down faster. This means lower fuel costs, faster inspection.

3. Furnace temperatures can be changed quickly. When different steels call for different heating schedules, the furnace temperature can be adjusted in minutes instead of hours.

4. Installation costs are lower because these lightweight brick can be handled faster and easier than ordinary heavy firebrick.

For complete information on B&W IFB—the *lightest* weight insulating firebrick, write to B&W today or call your local Refractories Engineer.

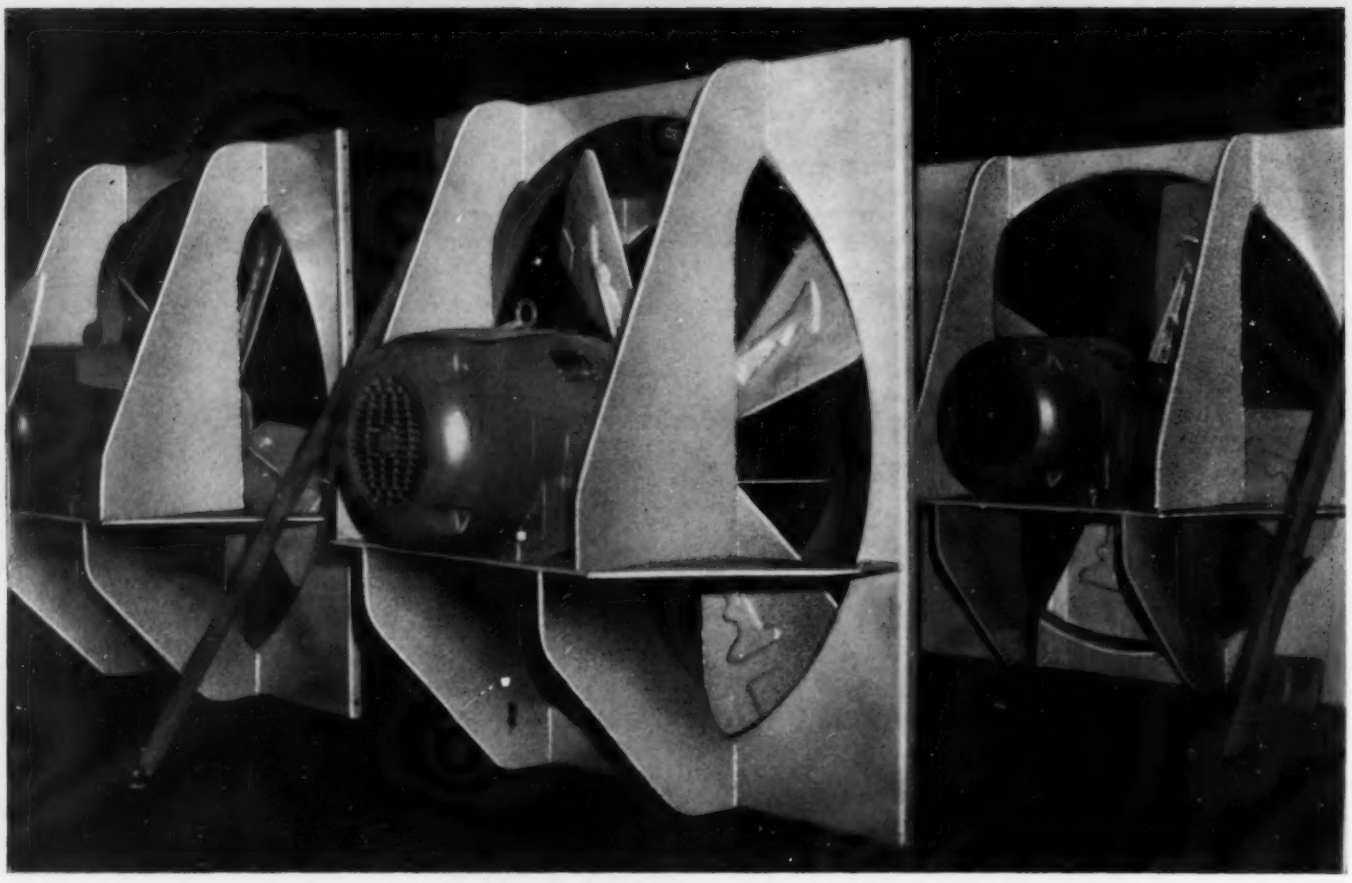


This is a cross-sectional drawing of a typical suspended arch arrangement using B&W Insulating Firebrick. It can be used in flat or sloping roofs, nose arches and many other types of suspended furnace construction.

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 161 EAST 42nd ST., NEW YORK 17, N.Y.
WORKS: AUGUSTA, GA.

R 535



Part of eleven "Buffalo" 54" Package Fans now ventilating the mill motor room of a large eastern strip mill.

Steel Plant SOLVES TOUGH MILL MOTOR ROOM VENTILATION PROBLEM with "Buffalo"

PACKAGE PROPELLER FANS

These heavy duty ruggedly constructed units are gaining wide acceptance in steel mill installations. Here, eleven of the above "Buffalo" units pull outside air in thru two banks of cleanable and electrostatic filters, discharging into the mill motor room. They're built to take this tough air moving job, too! Note the sturdy ¼" steel plate square flanged panels and the ⅜" steel plate support gussets welded to the panels. The heavy die-stamped blades are welded to rugged cast steel spiders. Motors are 15 h.p., 860 R.P.M.

What hot spots in your plant would you like to ventilate at propeller fan cost? "Buffalo" offers you the complete selection — sizes up to 144" wheels — power roof ventilators — all kinds of special models to suit your application. Write today for Bulletin FM-1234 and see the astonishing variety of jobs these "Q" Factor* fans are doing well and inexpensively.

**The "Q" Factor — the built-in Quality which provides trouble-free satisfaction and long life.*

"Buffalo"

BUFFALO FORGE COMPANY

BUFFALO, NEW YORK

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT EXHAUSTING
FORCED DRAFT COOLING HEATING PRESSURE BLOWING

Ore to be sintered at the Gary plant will arrive by lake boats which are unloaded near the sintering facility. The Saxonburg plant will receive its raw materials by rail.

J&L BEGINS EXPLORATION FOR ORE IN WISCONSIN

▲ Jones & Laughlin Steel Corp.'s search for additional reserves of iron ore has been extended to Ashland County, Wis., where J&L has started an exploration program on lands it has optioned.

The properties are located near the Village of Butternut and in the Township of Agenda. They include approximately 1,600 acres. The acreage is owned by 15 different private individuals.

Options, which terminate at the end of 1957, were negotiated for purchase of some of the properties and for lease of others, if the exploration work indicates iron bodies in economic quantities. Diamond drilling is being done under contract with E. J. Longyear Co., Minneapolis, Minn.

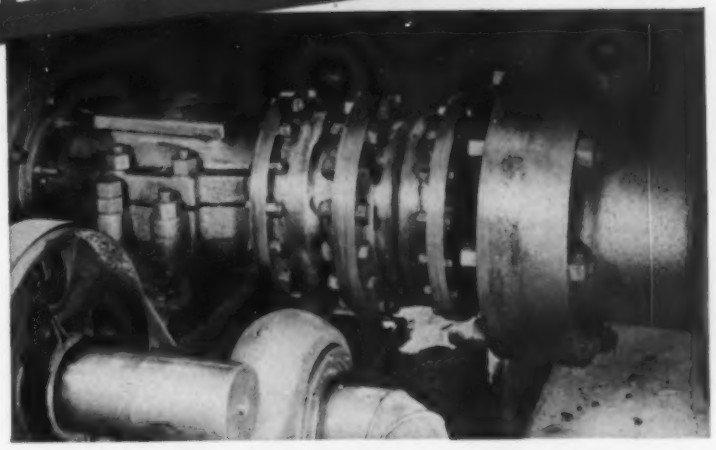
These new explorations are about 35 miles away from another J&L exploration site on lands owned by Iron County, Wis. The Iron County lands are located in the Pine Lake area north of Mercer. They are being explored under an option agreement initiated in 1955.

The decision of the corporation to option the Ashland County properties and explore for iron ore was reached after preliminary geophysical surveys indicated the possible presence of economic quantities of magnetic iron formation or taconite which might be recovered by open pit mining.

Detailed geophysical surveys are being conducted to supplement the present diamond drilling program, which will be completed this year. If preliminary exploration results are favorable, additional drilling will be done in 1957 to outline in more detail the ore bodies within the optioned areas.

Another J&L exploratory site is located in the Province of Quebec, Canada, 200 miles north of the iron ore port of Seven Islands and 40 miles from the Quebec, North Shore & Labrador Railway. J&L recently announced plans for a two-year exploration of this site. Drilling is scheduled to begin this summer.

SPECIFYING A GEAR TYPE COUPLING IS NOT ENOUGH



Unretouched photo of WALDRON Heavy Duty Coupling between speed reducer and mill at Crucible Steel Co. of America, Syracuse, N. Y.

For An *Advanced* Gear Type Coupling, Leading Users Specify

WALDRON

As one of the oldest builders of couplings, WALDRON was first to introduce the modern refinements in the usual gear type design. Today's WALDRON Gear Type incorporates construction and operating advantages that insure greater dependability with less maintenance resulting in substantial savings over longer service life.

Such features as its forged steel construction, solid unit cover sleeve, longer lining up surface, oil film protection against wear, larger bore and less rotating weight are but a few of the reasons why it is the preferred gear type coupling in all industries.

Whatever your drive problem; there's a WALDRON Coupling to meet it. All steel for rugged work, all nylon where corrosion problem exists, combination of both for special applications.

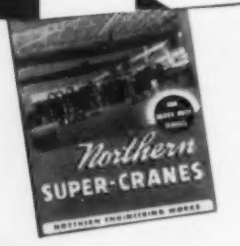
JOHN WALDRON CORP. • NEW BRUNSWICK, N. J.

Sales representative in Principal Cities

Export Agents • Frazar & Company, Inc.

STANDARD TYPES — Waldron COUPLINGS — SPECIAL TYPES

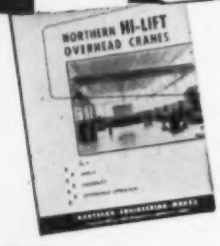
NORTHERN SUPER CRANES • UP TO 150 TONS



Northern Super Cranes—since 1899—have been moving endless tonnages of material in thousands of plants in the United States and other countries. For safety, durability, precise manipulation, unsurpassed electrical equipment, minimum maintenance and maximum dependability in heavy duty service, many plant managers have installed Northern Cranes exclusively.

Write for Bulletins SE-108-A and G-700

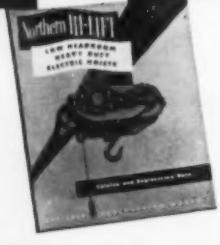
NORTHERN HI-LIFT CRANES • UP TO 20 TONS



Northern Hi-Lift Cranes are intended both to supplement Northern Super Cranes in heavy duty service and to provide economical work handling in lighter service. They have the same engineering features as Northern Super Cranes—low design stress for safety—high grade steels, turned and ground shafts and press fits for durability—highest quality electrical equipment and controls for dependable operation.

Write for Bulletin HL-115-R

NORTHERN HI-LIFT HOISTS • 2 TO 15 TONS



Northern Hi-Lift Hoists are heavy duty type electric hoists, designed especially for low headroom installations. They feature heavy duty roller bearings, extra heavy bearing shafts accurately press fitted with bearing races, extra large independent mechanical and electric brakes, and many other elements required in a good investment in hoist equipment.

Write for Bulletin H-112

NORTHERN TRAVELATORS • FOR LIGHT CRANES

The Northern Travelator is a bridge drive unit which can be applied to a hand traveled crane to convert it to power travel. It can be easily installed by your own mechanics and electricians in a few hours time. The roller chain drive facilitates installation and provides longer life and greater ability to absorb the usual impacts of crane service.

Write for Bulletin T-105

NORTHERN CRANES—HOISTS—TRAVELATORS

NORTHERN ENGINEERING WORKS
210 CHENE ST., DETROIT 7, MICH.

AWARDS SLABBING MILL CONTRACT TO UNITED

▲ The United Engineering and Foundry Co. has received an order from Republic Steel Corp. for a 45-in. x 90-in., 2 high universal slabbing mill for its Corrigan-McKinney Works, Cleveland, Ohio.

The order includes the necessary auxiliary equipment for ingot handling through to the shearing and piling of finished slabs. The mill will be powered by two 6000 hp electric motors and will have an edger driven by one 4000 hp motor. It will handle ingots up to 47,000 lb.

The manufacture of the mill is expected to be completed early in 1957.

MESTA TO BUILD HOT STRIP MILL FOR KAISER

▲ A contract covering machinery required to increase the output of the 86-in. hot strip mill, in connection with the large expansion program of Kaiser Steel Corp.'s Fontana, Calif., Plant, has been awarded to Mesta Machine Co. by Kaiser Engineers, Division of Henry J. Kaiser Co.

New equipment furnished by Mesta for this mill will include slab furnace charging and delivery equipment, scale breaking stand, spreading mill for broadside rolling, slab squeezer, vertical edging mills and four universal roughing mill stands.

Auxiliary mill equipment will include conveying tables, roll changing equipment, hydraulic roll balancing equipment, and lubricating systems.

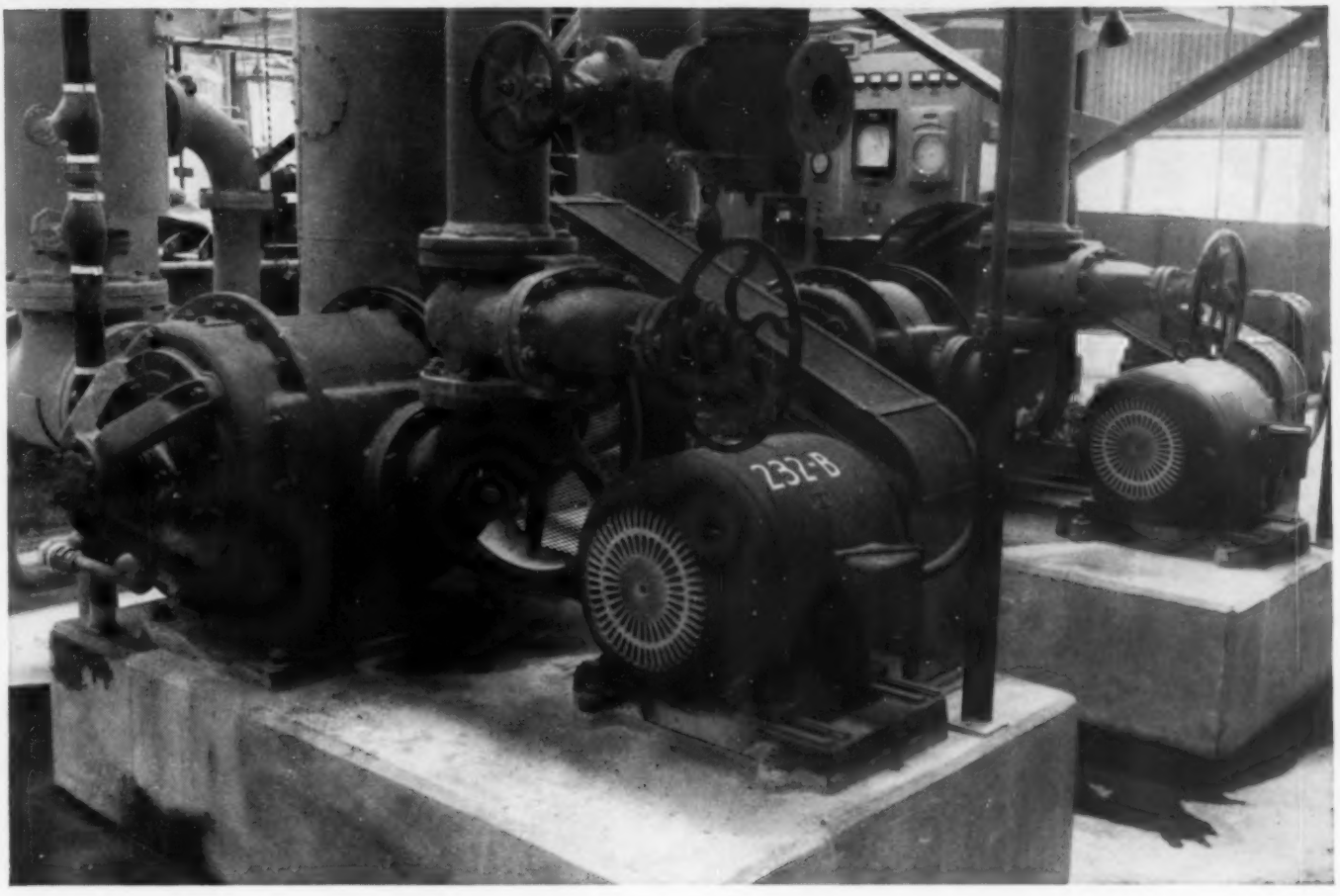
COKE OVEN CONTRACT AWARDED TO KOPPERS

▲ Koppers Co., Inc. has been awarded a contract by Republic Steel Corp. to rebuild a coke oven battery with auxiliary equipment at the Cleveland, Ohio works.

The 51-oven battery, originally built by Koppers in 1918, will be rebuilt to increase its capacity approximately 25 per cent. When completed approximately 1,000 net tons of coal will be carbonized per day to produce 700 net tons of furnace coke per day. Auxiliary equipment to be designed and constructed by Koppers will be a flushing system, a coke quenching station and a system of coal mixing bins. There are four batteries of coke ovens at the Cleveland works.

Rebuilding the battery and the installation of new auxiliary equipment is expected to be finished by the middle of next year.

WAGNER ELECTRIC MOTORS...THE CHOICE OF LEADERS IN INDUSTRY



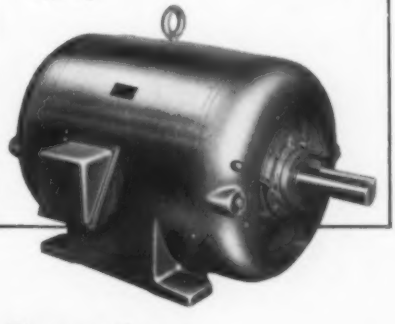
Designed for use in steel mills
WAGNER EP MOTORS

Here are stock motors specifically designed for the steel industry—they're fully protected against corrosive fumes and liquids, dust, dirt or moisture.

Such protection is assured by totally-enclosed fan-cooled construction in corrosion-resistant cast iron frames. Extra protection is given the laminations by a wall of cast iron that completely surrounds the stator. Even though the windings are completely enclosed, they are treated with a special coat of varnish that resists acids and alkalies. A running shaft seal, sealed leads and a gasketed conduit box give still further protection to these motors.

A skilled Wagner engineer, expert in motor applications, can help you select the Wagner Motor that meets your most exacting specifications. Call the nearest of our 32 branch offices, or write us.

Wagner Type EP—JP Motors are available in ratings from 1 to 250 hp in standard (Type EP) and explosion-proof (Type JP) designs, and in Non-ventilated corrosion-resistant standard and explosion-proof types in ratings from ½ through 1½ hp.

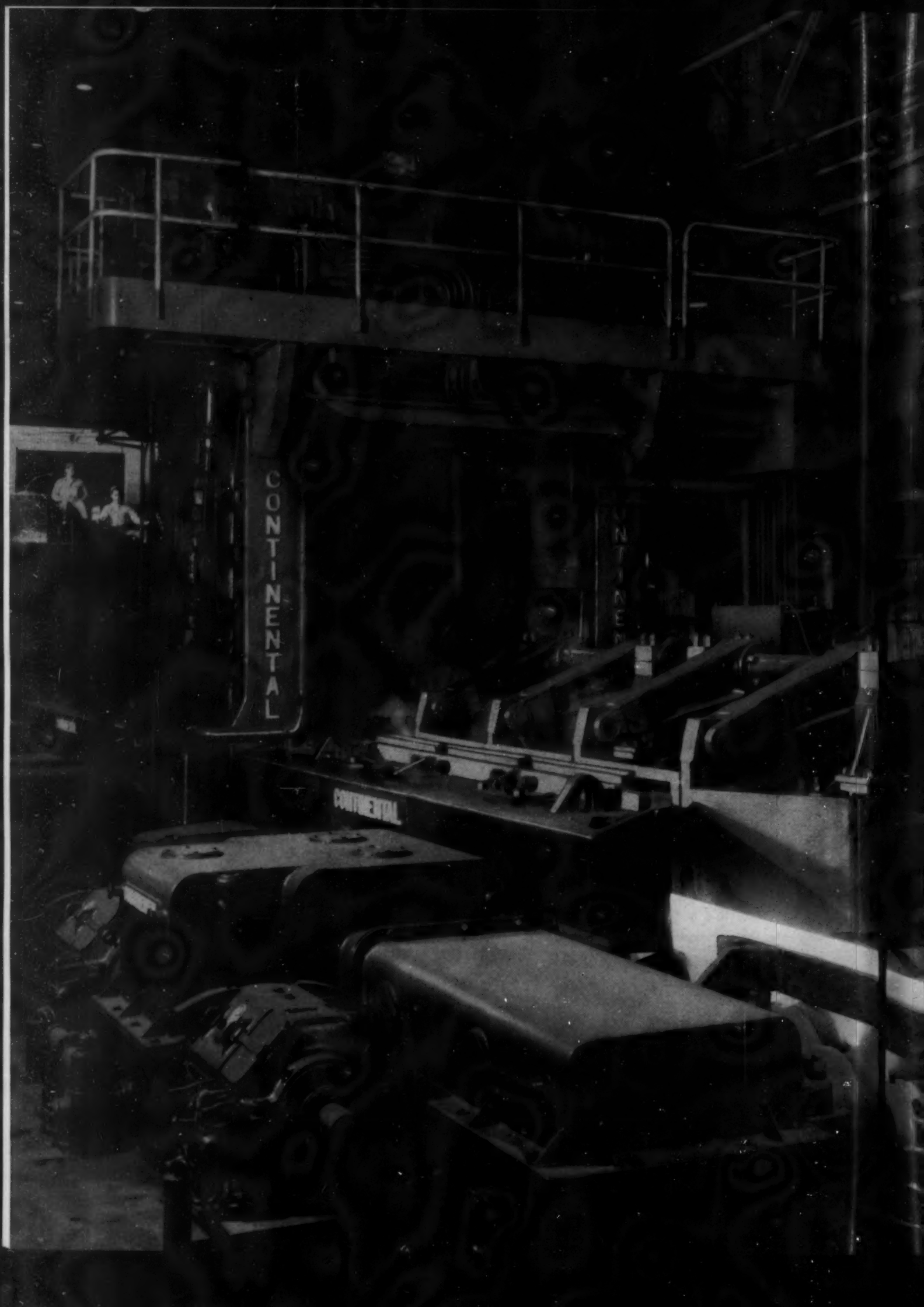


Wagner Electric Corporation
6483 Plymouth Ave., St. Louis 14, Mo., U.S.A.

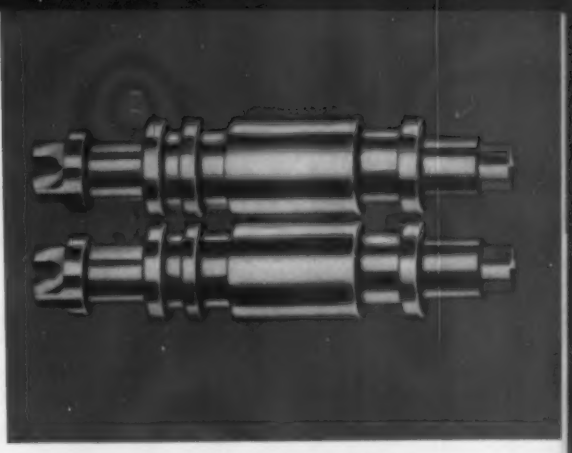
BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

M56-10A

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC


CONTINENTAL
CONTINENTAL

CONTINENTAL 40-inch, 2-high reversing blooming-slabbing mill in the Fairless Works of the United States Steel Corporation.



ROLLS—iron, alloy iron and steel rolls for all types of rolling mills.

BLAW-KNOX

makes what it takes

to handle tough

blooming-slabbing

operations

CASTINGS—carbon and alloy steel castings from 20 to 250,000 pounds.

In operation as an intermediate mill for subsequent rolling, this rugged Continental 40-inch reversing blooming-slabbing mill is providing excellent performance in the United States Steel's Fairless Works.

Variations of the basic design of this mill are built by Blaw-Knox to serve as break-down mills for billet and bar mills, rail and structural mills, and merchant mills.

Blaw-Knox designs and builds complete rolling mill installations—assumes undivided responsibility from preliminary engineering to satisfactory operation. At any time we'll be glad to discuss your plans with you.

WELDMENTS—fabricated steel plate, or cast-weld design.

50th Anniversary

BLAW-KNOX

1906-1956

CONTINENTAL

BLAW-KNOX COMPANY

Foundry and Mill Machinery Division

Blaw-Knox Building • 300 Sixth Avenue

Pittsburgh 22, Pennsylvania

Complete Rolling Mill Installations . . . including all auxiliary equipment . . . for ferrous and non-ferrous metals

Hot strip mills • cold strip mills • slabbing mills • temper mills • universal mills • plate mills • blooming mills • structural mills • rail mills • billet mills • rod mills • merchant mills • roll lathes • chippers • special machinery • and complete auxiliary equipment

Exclusive with the Heroult:

100% Mechanical Operation

The Heroult is the *only* 100% mechanically operated electric furnace on the market! All of the movements are handled by motor-driven gear mechanism.

This is a very important advantage—as any engineer will readily tell you, for it eliminates so many maintenance difficulties.

There is nothing about the operation and servicing of the motor-driven, heavy-gear mechanism of the rugged Heroult that any good maintenance man can't easily take care of himself. Seldom, if ever, will you find it necessary to call in an outside maintenance man to keep your Heroult performing efficiently.

Modern Heroult electric furnaces are available in sizes ranging in holding capacity from 6,000 lbs. up to and in excess of 400,000 lbs. Both gantry and swing-type roof-moving mechanisms are available. Door-charging furnaces and furnaces of special design, including units equipped with austenitic steel bottoms to permit induction stirring, can also be supplied.

We welcome an opportunity to help you select and install the Heroult best suited to your requirements. An inquiry to the nearest office will bring complete details.

Heroult

ELECTRIC MELTING FURNACES

USS

AMERICAN BRIDGE DIVISION

UNITED STATES STEEL CORPORATION, GENERAL OFFICES: 525 WILLIAM PENN PLACE, PITTSBURGH, PA.

Contracting Offices in New York, Philadelphia, Chicago, San Francisco, and other principal cities.

United States Steel Export Company, New York

SEE THE UNITED STATES STEEL HOUR. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

UNITED STATES STEEL

FOR

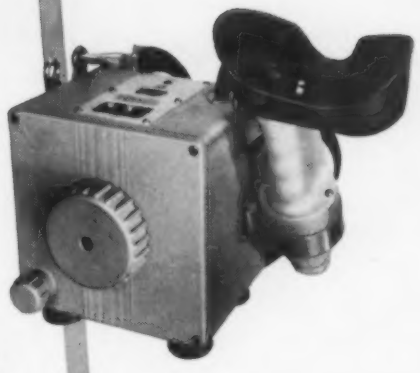
"on-the-spot" checking...

INVESTIGATE THESE WIDELY-USED TEST SETS

In appearance, the 8657-C Indicator is typical of L&N portable test sets and is outstanding for fully dependable, moderate precision. The portable series also includes instruments for measuring temperature, electrolytic conductivity, electrical resistance and pH.

High on any list of "musts" for making spot-checks of production processes and equipment are these L&N Test Sets. For these versatile instruments combine the portability, ruggedness and simplicity of design needed for plant use, with the accuracy and flexibility necessary for use in the laboratory.

Specifications for just a few of these instruments appear below. For more complete information, contact our nearest office or write 4942 Stenton Avenue, Philadelphia 44, Pa.



The L&N Optical Pyrometer—Direct reading in degrees, this compact instrument enables users to measure the temperature of glowing objects quickly and accurately.

FOR THERMOCOUPLE EMF MEASUREMENT

Instrument	Application	Range	Limit of Error	List Number
Double-Range Portable Millivolt Indicator	For thermocouple voltage measurements. Reads in millivolts. Manual reference junction compensation.	Indicator: 0 to 16 mv 16 to 64 mv Compensator: 0 to 1 mv 0 to 5 mv	Low Range: ±0.3% High Range: ±0.3%	8657-C
	A more precise instrument for thermocouple voltage measurements. Reads in millivolts. Manual reference junction compensation.	Indicator: 0 to 16.1 mv (15 x 1 mv + 1.1 mv slidewire) 0 to 80.5 mv (15 x 5 mv + 5.5 mv slidewire) Compensator: 0 to 1 mv 0 to 5 mv	Low Range: ±0.01 mv High Range: ±0.05 mv	8662

FOR TEMPERATURE MEASUREMENTS

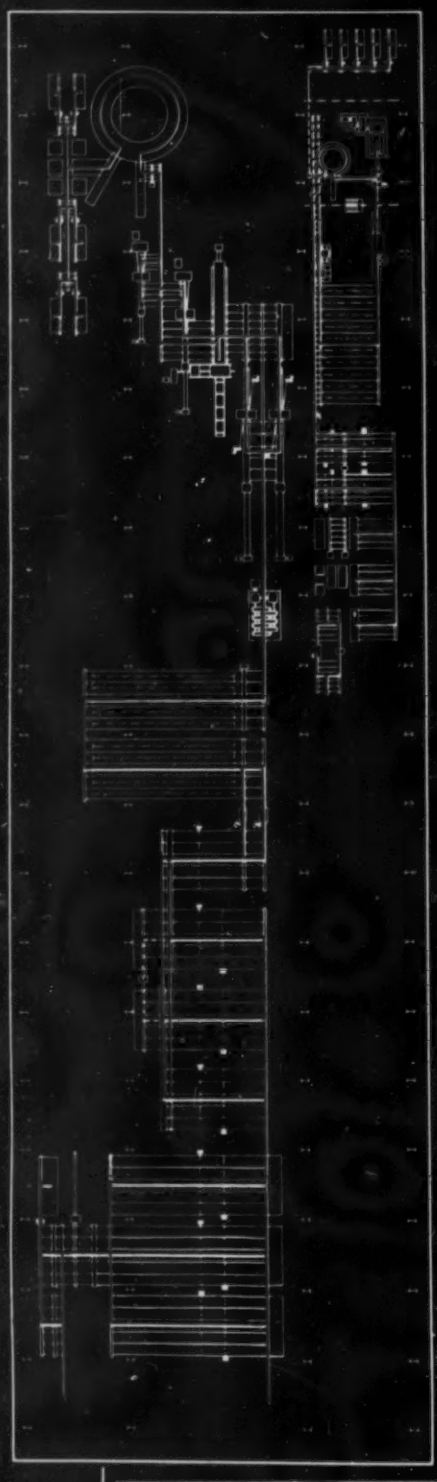
Optical Pyrometer	For temperature measurements of flues, kiln linings, or other objects.	1400-3200 F 775-1750 C 1400-5200 F 775-2800 C	— — — —	8621 8621-C 8622 8622-C
	For temperature measurements of molten iron, steel, or other material having an emissivity of 0.4.	1400-3200 F 775-1750 C	— —	8623 8623-C
Optical Pyrometer Test Equipment	For checking potentiometer-type L&N optical pyrometers by the substitution method, using a plant standard. Operates on 115 v, 60, 50, or 25 cycles, as specified.	Adjustable transformer varies input voltage to test lamp to simulate checking temperature to approximately 3000 F.	—	10625

FOR RESISTANCE MEASUREMENTS

Type S-1 Test Set	For general resistance measurements. Includes provisions for locating grounds and crosses by the Murray and Varley Loop tests.	Useful range: 1 to 50,000 ohms, direct measurement. Will measure approximate resistance at lower and higher values.	±0.15%	5300

LEEDS NORTHRUP

instruments automatic controls • furnaces



Is there a standard way to build a tube mill?

Not according to what we've learned in many years of building and equipping tube and pipe mills.

Mannesmann-Meer's NO to this question is dictated by two factors – the individual needs of our various customers and the steady progress we build into our equipment.

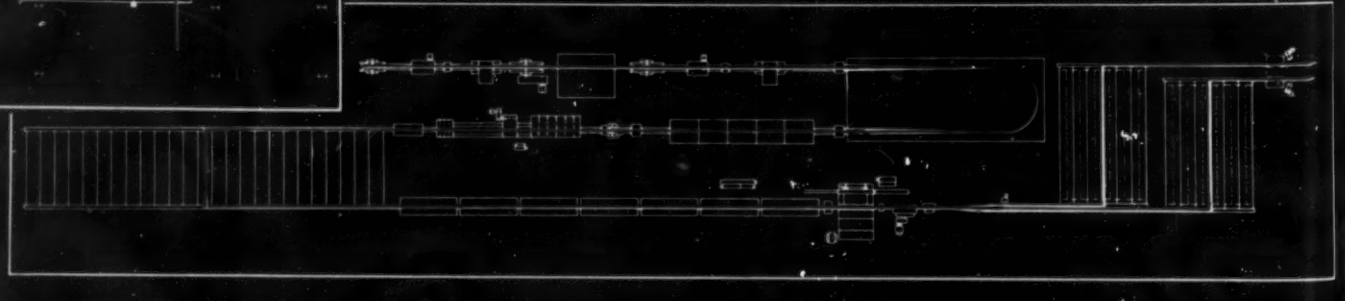
Here is an example. Economic needs and often other considerations lead many Companies into installing a new mill step-by-step. This procedure sometimes has marked advantages which show up in the mill layout and in the integrated planning for future steps of expansion, all of which will then be up-to-date. On the other hand mills for certain tubular products which must be installed all at once present different problems in plant engineering – with different solutions.

Meeting your individual needs and requirements is second nature for us. Nowhere else in the world is Mannesmann-Meer's combination of

- CREATIVE ENGINEERING
- DESIGN EXPERIENCE
- OPERATING BACKGROUND
- AMERICAN MANUFACTURING SKILL

available and ready to go to work on your tube and pipe mill problems.

Mannesmann-Meer Engineering and Construction Company, Inc.,
900 Line Street, Easton, Pennsylvania



MANNESMANN-MEER

World Specialists in High-Speed Tube Mill Machinery

Look Boss... No Hands!

Gauging and controlling of steel thickness or width, hot or cold, is no longer a hand operation. It is automatic. One of our many types of precision gauges and controls is the
XactRAY NON-CONTACT PIPE WALL GAUGE

PRODUCTS for STEEL MILLS:

Non-Contact Gauges
- XactRAY PIPE WALL GAUGES to automatically mark over- and under-size wall.
- XactRAY THICKNESS GAUGES for hot and cold strip.
- XactRAYMATIC CONTROLS for automatic control of strip thickness.
- INFRA-RAY WIDTH GAUGES for hot strip.
- INFRA-RAY DIAMETER GAUGES for hot rolled rod.

Other Equipment:
- PRODUCT ANALYZERS— Printed Record of % of strip within several tolerance ranges.
- SOLIDIFICATION POINT INDICATORS— Speed casting operations.
- WEIGHT INTEGRATORS— for conveyor belts.
- INFRA-RAY RELAYS— for automatic actuation.
- LOAD RELAYS— Sensitive and easily adjusted.

This X-ray tool measures pipe wall thickness within 1% accuracy. It detects and automatically marks crop points of rolled, stretch-reduced, or extended pipe. It also indicates average wall through one or both walls. SPECTACULAR SAVINGS are achieved in major mills by elimination of wasteful blind cropping of seamless tubing, re-processing, re-inspection and re-handling. The entire mill output—from 3 to 5 lengths per minute—is checked. RANGE OF THICKNESS AND MATERIAL: .010″ to 2.000″ of coated and uncoated steel, stainless, brass, copper, bronze, zinc, titanium; .00025″ to 10.000″ of aluminum, magnesium, and non-metallics. Diameter of pipe or cylinders can be from 1″ to 30″.

Many of the largest steel mills in this country and Europe are lowering production costs by using our equipment. Do you know where our equipment is operating in your mill?

Let Industrial Gauges non-contact gauges and control systems do the work for you . . . producing better products . . . with substantial savings—savings that pay for our equipment within weeks or months, not years. Write or telephone

Englewood 3-4389

IGC

INDUSTRIAL GAUGES CORPORATION

ENGLEWOOD, NEW JERSEY

View of blast mains showing the 3-way split.

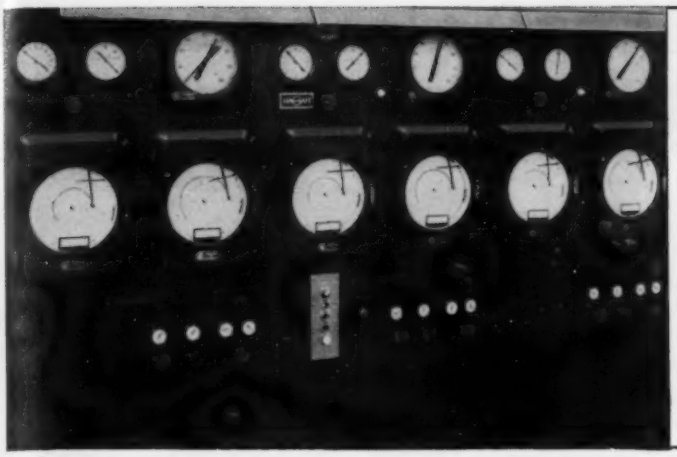
HAGAN perfects split

Installed at Duquesne Works of U. S. Steel

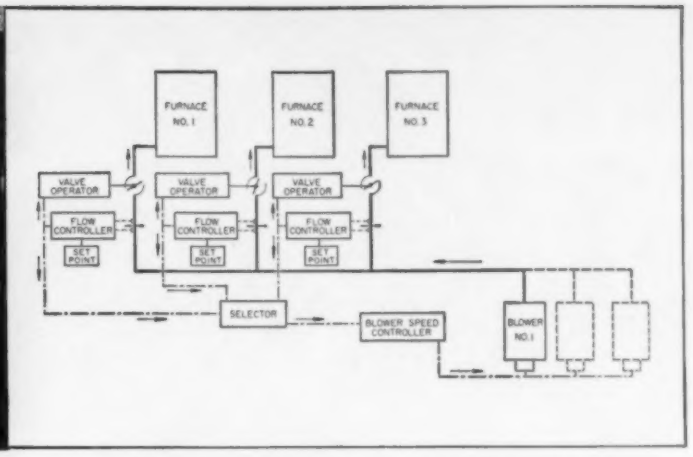
Now in successful operation on blast furnaces at the Duquesne Works of U. S. Steel, the Hagan control system assures high efficiency and operating economy by means of a new approach to the problem of split wind blowing.

1. Instead of throttling all cold blast control valves, the Hagan System automatically selects the furnace requiring the highest blast pressure and holds the control valve for this furnace wide open, at the same time controlling flow to this furnace by varying blower speed. Throttling takes place only on the other furnace flow control valves. Blower discharge pressure is held to a minimum.
2. The Hagan system maintains true air flow in scfm (30″ Hg. and 60°F) by means of *automatic* pressure and temperature compensation. Metering with Hagan Ring Balance Recorders is on the same basis.

The Hagan split wind blowing control system is completely automatic. Once furnace air flow is set by the operator, the system automatically maintains the set air flow, adjusting to varying



Front of control panel for split wind blowing control of 3 furnaces.



Simplified block diagram of Hagan split wind blowing control system.

•

Detail of panel showing conditions of Furnaces 2 and 3 which are on split wind blowing. The first two dials for each furnace show blast pressure and valve opening; the dual indicator shows air flow set point and actual air flow.

Note that the control valve for No. 2 Furnace is held wide open and that the flow to No. 2 is being controlled by blower speed.

•

Under this condition, the total permanent pressure loss across the metering orifice and control valve is about 3″ w. c. at full blast.

Whenever Furnace No. 3 requires the higher blast pressure, the condition shown here will reverse. The control valve for No. 3 Furnace will open wide, with No. 2 throttled. Selection of the control valve requiring the highest blast pressure is automatic.

wind blowing control

conditions of air temperature, air pressure and furnace burden. The Hagan system may be used with any combination of furnaces and blowers in multiple. Accurate and reliable, Hagan controls make good housekeeping easy by using pneumatic transmission and control.

This new Split Wind Blowing Control is only one of the many Hagan advances in metallurgical furnace control. Ask your Hagan engineer for information on Hagan systems and Hagan components specifically designed for the control of open hearths, blast furnaces and heat treating furnaces.

HAGAN CORPORATION
HAGAN BUILDING, PITTSBURGH 30, PA.

HAGAN

Systems and Components for: Boiler Combustion Control, Metallurgical Furnace Control, Process Control, Aeronautical Testing Facilities • Industrial Water Treatment • Chemicals for Water Conditioning

HAGAN SUBSIDIARIES: CALGON, INC. • HALL LABORATORIES, INC.

MAKE A DATE WITH SAVINGS...

Arrange for your men to see and hear

National Carbon's

new electrode shop training program

Here's a must for operating, supervisory, purchasing and management personnel . . . any one concerned with the procurement, storage, handling or use of electrodes. It's available free — in your own plant or any other mutually convenient location. Thorough coverage of the manufacturer's recommendations for proper electrode usage . . . illustration and demonstration drive home the fundamentals of good electrode practice . . . help you get top value from every electrode dollar.

- Product quality recognized to be the highest in the industry.
- New end-caps — protect sockets from dust, dirt and end-face chipping.
- New pin package — quicker identification, easier handling and storage.
- Complete technical service — designed to extend the service normally provided by field salesmen.

Write or call right now for complete details of the new electrode training program and arrange to have this important educational demonstration put on for your personnel.

For Electrodes and Electrode Service . . . rely on National Carbon Company

The term "National" is a registered trade-mark of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY . A Division of Union Carbide and Carbon Corporation

30 East 42nd Street, New York 17, N. Y.

Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco
In Canada: Union Carbide Canada Limited, Toronto

Personnel News...

Norman B. Obbard, formerly president of American Bridge Division, was appointed an assistant executive vice president—operations of United States Steel Corp. **Austin J. Paddock** succeeds him as president of American Bridge. Mr. Obbard began with Truscon Steel Co. as a draftsman in 1924 and two years later joined American Bridge as an engineer in the tower department. He became assistant to vice president, sales, in 1940. Two years later he was assigned to manage the shipyard division of the Ambridge, Pa., plant. In 1945, he returned to the Pittsburgh office as assistant to vice president and in 1946, was made vice president and general contracting manager. In 1954 he was made president of the American Bridge Division. Mr. Paddock began working with American Bridge as a timekeeper in the erecting department in 1929. In 1934 he was appointed assistant to manager of the bridge company's Elmira plant and in 1937 advanced to plant manager. In 1941 he was transferred to the Gary plant where he was manager for five years. In 1946, Mr. Paddock was appointed vice president in charge of manufacturing operations and in 1954, vice president in charge of contracting, the position he held until his present appointment.

Lyle F. Gulley, works manager of the Granite City Steel Co., has been appointed vice president in charge of operations. He succeeds **Nicholas P. Veeder**, who was recently elected executive vice president of the company.

William R. Gealey has been appointed superintendent of the rolling department of the Butler, Pa. Works of Armco Steel Corp. Mr. Gealey was formerly assistant superintendent of the rolling department.

Harold A. Muttach, divisional superintendent of coke ovens, blast furnaces, open hearths and foundry for the Granite City Steel Co., has assumed the additional duties of assistant to the vice president in charge of operations. At the same time, **Frank J. Burgert** was promoted from superintendent of North Plant to assistant to Mr. Muttach, and **L. Ovid Sperry** was made superintendent of the North Plant.

Frank J. Schaeffer was appointed director of industrial relations for United States Steel Corp.'s National Tube Division. He succeeds **Warren S. Burchinal** who has retired. At the same time **Gray D. Hobby** was appointed assistant director of industrial relations succeeding Mr. Schaeffer.

A. R. Attebury has retired as district manager for Timken Roller Bearing Co.'s Steel and Tube Division in New York. He will be retained as a sales consultant specializing in Timken pressure tubing. Mr. Attebury last February celebrated his 41st year in the steel industry and up to the time of his retirement had been with Timken 22 years.

H. C. Lynch has been named vice president for engineered products of the Wellman Engineering Co. He was one of seven new vice presidents named by Wellman. Others named include: **W. F. Avery**, for purchases; **Cresswell Ramsey**, for production; **Ray Mack**, for the Locomotive Crane Division; **John J. McGlone**, for the Williams Bucket Division; **W. L. Komph**, for sales and engineering of the Anker-Holth Division; and **F. J. Theisen**, for production at Anker-Holth.

E. R. Hall has been appointed vice president and general manager of the Metal Products Division of Koppers Co., Inc. He succeeds **Walter F. Perkins** who has retired. At the same time, announcement was made of the appointment of **H. B. Cummings** to succeed Mr. Hall as vice president and assistant general manager of the division.

Wallace B. Hunter was named vice president-contracting for U. S. Steel Corp.'s American Bridge Division. He was previously senior contracting manager at the New York office.

Carl W. Petersen, previously vice president and works manager of Dodge Manufacturing Corp., was elected executive vice president. **Earl Wedlake** was elected vice president in charge of production and purchasing. **Karl D. Jahnke** was promoted to the offices of secretary and treasurer to succeed **Temple Williams** who has retired. Mr. Williams remains a member of the board of directors and chairman of the finance committee of the board. **Lloyd F. Lamm**, who has been since 1944 vice president and general manager of Chi-

NORMAN B. OBBARD

AUSTIN J. PADDOCK

LYLE F. GULLEY

WILLIAM R. GEALEY

WILLIAM H. KINNEY

COLONEL W. L. McCULLA

A. H. JACKSON

LLOYD R. COOPER

cago Thrift-Etching Corp. and its predecessor, was elected president of this Dodge subsidiary.

William H. Kinney has been appointed assistant to the vice president, operations, for Kaiser Steel Corp. Mr. Kinney was previously resident metallurgical engineer for the company.

Colonel William L. McCulla, formerly vice commander, Arnold Engineering Development Center, Tullahoma, Tenn., has been named chief engineer of Superior Steel Corp. He joins Superior after 26 years of service in Army Ordnance and the Air Force.

A. H. Jackson has been named vice president-general manager of Blaw-Knox Co.'s Equipment Division Plant at Blawnox, Pa. Mr. Jackson succeeds **Capt. E. C. Rook,** who recently was advanced to vice president-general manager of the Fabricated Products Group, consisting of five divisions operating five plants and auxiliary facilities.

Lloyd R. Cooper has been named chief metallurgical engineer of Heppenstall Co. Mr. Cooper was a metallurgist with U. S. Steel Corp. from 1936 to 1942, when he joined Heppenstall. After serving as a research metallurgist, he was named acting director of research in 1946. He became the steel forgings firm's director of research in 1948. In 1952, he was named chief metallurgist of the plant in Eddystone, Pa. which Heppenstall Co. reactivated for the U. S. Air Force. When that plant was closed, Mr. Cooper returned to Pittsburgh. For the last several years he has been the company's assistant chief metallurgical engineer.

Milton H. Perry has been appointed Southeastern district sales manager of the Duraloy Co. His territory covers N. C., S. C., Ga., Fla., Ala., and eastern Tenn.

Robert L. Brown, Jr., former assistant sales manager of gas, diesel and LP-gas powered industrial lift trucks, has been named electric truck sales manager by the Yale & Towne Manufacturing Co.

Clemens C. Sutinen has joined the staff of the Mannesmann-Meer Engineering and Construction Co. as technical sales engineer with the Powder Metallurgy Equipment Division. His former connections include the Mechanical Manufacturing Division of General Mills, Inc., E. A. Laboratories, Inc., and the Welded Carbide Tool Co., Inc. where he worked on research and development projects in powder metallurgy.

Warren E. Erbe was appointed assistant manager, Transportation Division, Electric Service Manufacturing Co. Mr. Erbe has been with the company's sales department since 1943. Prior to his new assignment he was district sales manager in St. Louis, Mo.

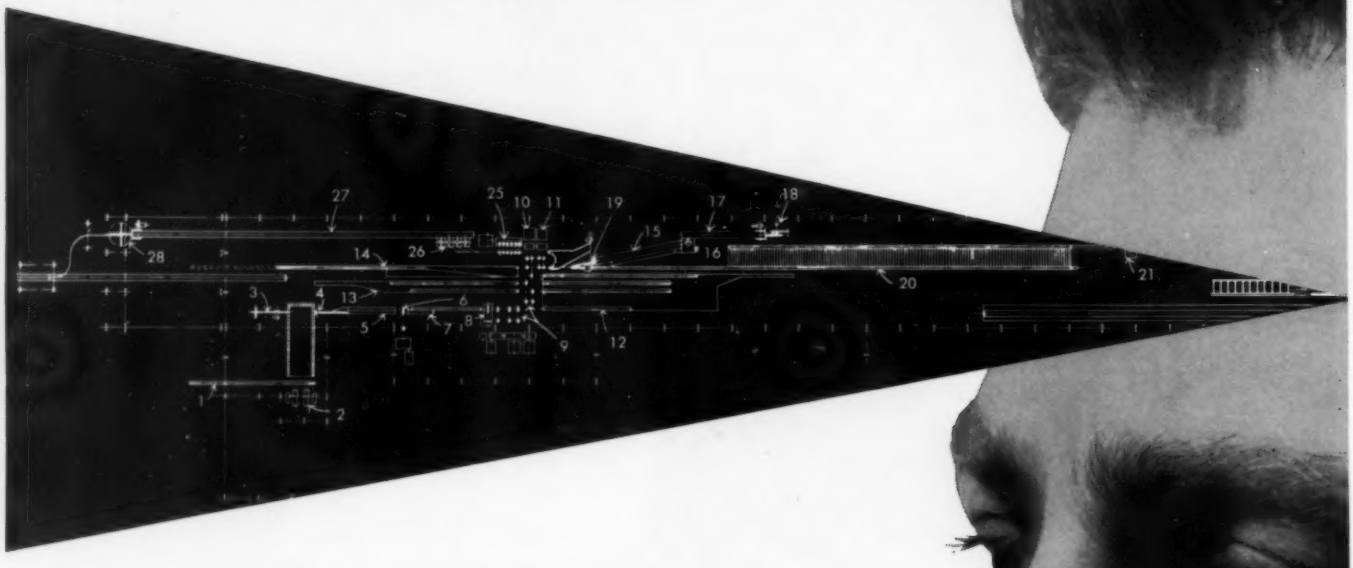
E. Ralph Gibbs was appointed Pittsburgh district manager of Koppers Co., Inc., Metal Products Division. He replaces **Emmett F. Cary** who has retired.

E. RALPH GIBBS

James A. Dunn has been appointed manager of the Trenton, N. J. plant of U. S. Steel's American Bridge Division, succeeding **G. K. Manzer** who will move to Pittsburgh to become assistant to director of industrial engineering. Mr. Dunn joined American Bridge in 1937 as a draftsman. Two years later he was made a foreman in the barge yard at the Ambridge, Pa. plant and was successively assistant superintendent of marine building and then superintendent of that depart-

LOOKING FOR
NEW IDEAS?
GO SEE-
THE 1956 IRON & STEEL EXPOSITION
CLEVELAND PUBLIC AUDITORIUM
SEPTEMBER 25—28
No Admission Fee • No Registration Charge
Open to Men of the Iron and Steel
and Allied Industries
★ Tell-ALL Exhibits
More than 200 companies that supply materials, equipment and services to the Steel Producing Industry will reveal their latest advances in eye-catching, informative displays and demonstrations.
★ Vital Technical Sessions
Four full days of intensive technical sessions offer a liberal education in "What's New" in steel plant operation, methods, planning, maintenance and many other pertinent subjects.
1956
IRON AND STEEL EXPOSITION
The Industry's Most Specific Show!
For additional information, write
Association of Iron & Steel Engineers, 1010 Empire Bldg., Pittsburgh 22, Pa.

Can improved plant layout increase your production capacity?



the answer may be here...

. . . because BIRDSBORO is more than a producer of mill machines. We're designers and planners . . . combining engineering knowledge with *ideas*. Tough mill problems are constantly being brought to BIRDSBORO for solution, and the answers often lead to tangible increases in productivity, lower costs. Call your BIRDSBORO representative. Ask him to put this proven engineering ability to work for you.

DESIGNERS AND BUILDERS OF:

- STEEL MILL MACHINERY
- HYDRAULIC PRESSES *(Metalworking and Extrusion)*
- CRUSHING MACHINERY
- SPECIAL MACHINERY
- STEEL CASTINGS
- Weldments "CAST-WELD" Design
- ROLLS: Steel, Alloy Iron, Alloy Steel

Not just machines— but ideas, too!

MM 50-56

BIRDSBORO

BIRDSBORO STEEL FOUNDRY & MACHINE CO., Main Offices in Birdsboro, Pa. District Office: Pittsburgh, Pa.

New York Office: **Engineering Supervision Co.,** 120 West 42nd Street, New York 36, N.Y.

ment. In 1946 he became assistant plant superintendent at Ambridge, the position he held at the time of his Trenton appointment.

Donald E. Moat was appointed director of marketing for Leeds & Northrup Co. Mr. Moat became assistant director of marketing and member of the L&N executive operating committee last year; he had previously been manager of the company's Cleveland office.

Norman M. McGrane has been promoted to the post of chief technical engineer of Western Precipitation Corp., and also has been elected to the board of directors.

Philip J. Berg has been assigned to Dravo Corp.'s home office in Pittsburgh to handle sales engineering of DeLaval blast furnace blowers and Dravo-Lurgi sintering plants. Mr. Berg joined the company in 1946. He served in various engineering and sales positions, most recently as manager of the Detroit, Mich., office of Dravo's Machinery Division.

A. James Fisher has been appointed general sales manager of Metal & Thermit Corp. Mr. Fisher joined the Metal & Thermit organization in 1955, serving as technical advisor to the president.

Henry W. Kreifeldt has been named sales manager of Morton Manufacturing Co. He joined the company in 1935 as a draftsman, later becoming a design engineer of special machine tools. In 1951 he transferred to the Sales Department where he served as a sales engineer of both machine tools, special machinery and automatic welding machinery.

Captain Clifton G. Grimes, deputy chief of naval research, has been appointed director of research of the Electric Storage Battery Co., succeeding Dr. L. E. Lighton who has retired. Dr. Lighton joined Exide in 1920 as a sales engineer in the firm's Detroit, Mich., branch. After 15 years in sales he was transferred to engineering and was made manager of that department in 1940. In 1945 Dr. Lighton was elected vice president in charge of engineering, and early last year he was appointed director of research.

Edward J. Doolittle has been appointed field sales engineer of Loewy-Hydropress Division of Baldwin-Lima-Hamilton. Mr. Doolittle will represent Loewy-Hydropress in Ohio, W. Va. and Ky. He has been associated with Baldwin-Lima-Hamilton for 11 years.

Paul J. Wolfert has been appointed supervisor of export sales for Blaw-Knox Co. **H. T. Schwier,** formerly in charge of Blaw-Knox exports, has resigned and will represent the company in the foreign sales of rolls and rolling machinery, including steel plant equipment.

Walter P. Barrett has been appointed manager of the pipe fabrication department of Dravo Corp.'s Machinery Division. Mr. Barrett joined Dravo in 1935 and has served in various sales and administrative capacities including assistant to the president, manager of the Machinery Division's Philadelphia Office, and, most recently, manager of the division's New York Office.

Ives L. Harvey was appointed sales manager of Speer Carbon Products Division. **C. S. Boland** was named assistant sales manager of the division. In addition, **Millard S. May** was named manager of Technical Services for the Carbon Products Division. Mr. Harvey joined Speer as a development engineer in the company's research and development department, in 1946. Two years later, he was named assistant to the director of research. In 1950 he became an expediter and special representative, and in 1953 was appointed sales representative for the southeastern U. S. Mr. Boland joined Speer in 1926, and was named assistant to the sales manager in 1950. Mr. May joined Speer in 1920. Since then he has headed up an electrical testing laboratory, development laboratory, and the company's inspection and sales engineering programs.

William A. Anthony has joined the Gas Machinery Co. to head engineering and sales of a new line of continuous mixers. Mr. Anthony comes to Gas Machinery from the Colonial Iron Works Co. Also, **Hjalmar A. Anderson** has joined the firm as a sales engineer in the Industrial Furnace Division, and **Francis C. Shaffer** has become associated with the firm in research and development.

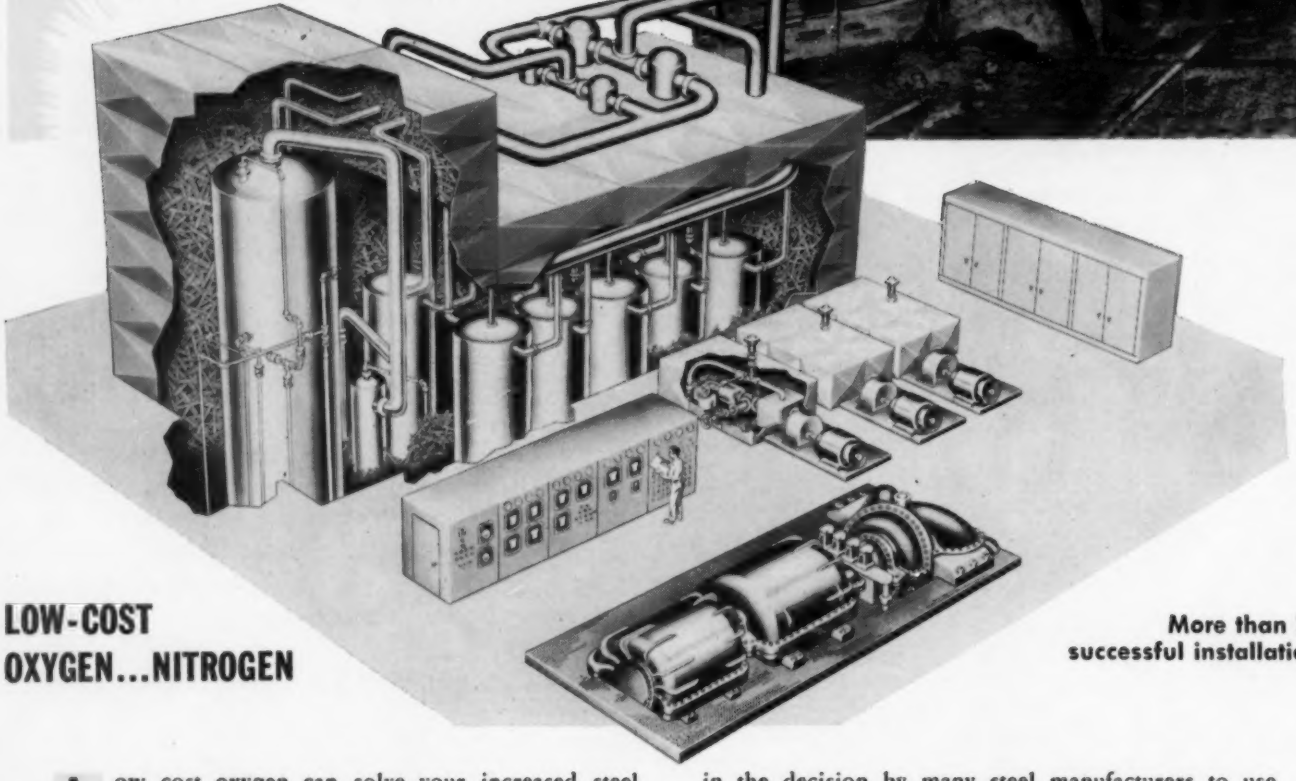
DONALD E. MOAT

NORMAN M. McCRANE

PHILIP J. BERG

A. JAMES FISHER

MORE STEEL WITH OXYGEN



LOW-COST OXYGEN...NITROGEN

More than 700 successful installations.

Low cost oxygen can solve your increased steel tonnage production problems.

The contrast between the extremely high capital investment needed for expansion of steel producing facilities and the remarkably low cost of oxygen available from Air Products generators has been the determining factor in the decision by many steel manufacturers to use oxygen in blast furnaces, open hearths, and steel converters for increased tonnage.

Air Products will install, *on a lease basis without capital investment by you,* an oxygen generating station specifically designed for your particular requirements.

We design and manufacture:

Large Capacity Tonnage Generators for unlimited quantities of oxygen and nitrogen regardless of size, purity or cycle

and

"Packaged" High-Purity Generators, producing high purity oxygen and nitrogen separately or simultaneously.

Let us help you investigate the possibilities of your tonnage increasing and save money with oxygen.

Air Products INCORPORATED **Dept. P, Box 538, Allentown, Pa.**

Walton S. Smith has retired as vice president in charge of manufacturing of Metal & Thermit Corp., after 37 years of service. He will continue as a director and consultant of the company.

Robert D. Cleaves was appointed manager of utility sales of I-T-E Circuit Breaker Co. **Hugh P. Maxwell** was named manager of distributor sales. Both appointments fill newly-created posts in the company's sales organization.

J. W. Greene was named director of industrial sales of Crane Co. at the same time **W. A. Burbine** was named director of heating sales. Both men have been promoted from their posts as district managers. Mr. Greene headed sales in the east. Mr. Burbine was in charge of sales operations in the mid-west.

Richard D. Owen, formerly industrial engineer, was named superintendent of the Ideal Foundry Division of Republic Steel Corp. in Newton Falls, O. He succeeds **W. N. Mullane** who has resigned.

Richard M. Parrish was appointed Los Angeles district sales manager of SKF Industries, Inc. He succeeds **William F. Weidner,** who is retiring after 35 years of service with the company. Mr. Parrish previously served as assistant district manager at Los Angeles. The appointment of **W. Henry Keire** as field engineer in the Los Angeles district was also announced.

Nils G. Goranson was appointed vice president in charge of export sales of the Ohio Knife Co. Mr. Goranson will be associated with the New York office of the company.

NILS G. GORANSON

Charles W. E. Clarke has retired as vice president and consulting engineer of United Engineers & Constructors Inc. He will remain on the board of directors until the end of 1956.

John B. Girdler has been elected assistant vice president of Vanadium Corp. of America, and will fill the newly created position of general manager of sales. Assistant vice president **Roy F. Hancock** will head in the corporation's new Sales Promotion Division. Mr. Girdler's former position as sales manager has been filled by **Raymond H. Filsinger Jr.,** formerly Pittsburgh district manager. In addition, **George W. Johnson** has been appointed manager of the newly unified Steel Foundry and Iron Foundry Divisions. **Howard H. Wilder** has been appointed assistant manager of engineering sales.

John P. Cartwright has been named sales manager, Industrial Sales, of Joy Manufacturing Co. Succeeding Mr. Cartwright as district manager at Washington,

JOHN P. CARTWRIGHT

D. C., is **Arnott J. Lee,** who has worked in various sales and sales promotion capacities since joining the company in 1934.

William N. Matheson, Jr. was named vice president of operations for Oliver Iron Mining Division, U. S. Steel Corp. Mr. Matheson has been associated with Oliver since 1933 and has been actively engaged as an operator and supervisor in charge of Oliver operations for the past 23 years.

Glenn E. Seidel has been appointed to the newly-created corporate position of vice president in charge of engineering for Minneapolis-Honeywell Regulator Co. Mr. Seidel has been a member of the company's engineering organization for nearly 14 years and since 1952 has been vice president in charge of engineering in the firm's Minneapolis, Minn., plants.

Stanley J. Mahurin, formerly district manager for Gould batteries, has been made Los Angeles sales representative for C & D Batteries. At the same time the company announced the appointment of **William H. Krapf** as sales representative in the Pittsburgh area.

John A. Matousek has been named assistant to the president of the Baker-Raulang Co. Mr. Matousek joined Baker-Raulang in 1950 as plant manager. Previously, he was division manager in Detroit, Mich., for the Hupp Motor Corp.

Richard G. Nolte has been elected as a vice president and general manager of Duff-Norton Co. Mr. Nolte, formerly vice president and assistant to the president, succeeds **E. M. Webb** who has retired after 38 years

of service. Mr. Webb will continue to serve on the board of directors and also will act as special consultant.

David L. Doty has been appointed assistant chief metallurgist at the Aliquippa Works of Jones & Laughlin Steel Corp. Mr. Doty succeeds **D. J. Taylor** who is retiring. **John T. Hodges** will assume Mr. Doty's former duties as assistant to the director—Technical Services Division. He formerly was contact metallurgist on Sheet Mill Products.

George A. Markell has been appointed assistant sales manager of the Elwell-Parker Electric Co.

B. R. Neely has been appointed assistant electrical engineer of Morgan Construction Co. Mr. Neely was formerly with the Industry Control Department of the General Electric Co. **George H. McMillen** has been appointed fluids engineer. Before joining Morgan Mr. McMillen was with the Lewis Machinery Division of Blaw-Knox Co. He will deal with the problems involving the application of lubrication systems, hydraulic systems, water and air to rolling mill equipment.

O. J. Skawden has been named vice president of Sutton Engineering Co. With the firm since 1927, Mr. Skawden will continue as chief engineer at the firm's Bellefonte, Pa., plant. At the same time, **Ray A. Bland** has been appointed sales manager of the company's Mechanical Equipment Department.

William F. Burchfield has been appointed supervisor and **Kenneth M. Spicer,** assistant supervisor of technical service in the International Nickel Co.'s Development and Research Division.

William E. Fischelis, Jr. was appointed manager of advertising and sales promotion of Exide Industrial Division, the Electric Storage Battery Co.

Dr. Russell C. Buehl, formerly chief of the Bureau of Mines Pyrometallurgy Laboratories in Pittsburgh, Pa., has joined the staff of Rem-Cru Titanium, Inc., to study and develop new melting techniques for titanium alloys.

Obituaries

R. E. Christie, vice president, Crucible Steel Co. of America, died June 27. Mr. Christie had been associated with Crucible since 1901, one year after the company was formed. Since that time, he has been manager of stainless sales, vice president of sales, executive vice president and a director of the company. He retired as executive vice president in 1953 and as director this year. He retained the title of vice president.

James Dale, of Dumcreiff House, Ashgill, Lanarkshire, Scotland, died on February 1. Mr. Dale was a blast furnace consultant for the past 12 years, and had previously engaged in blast furnace work at Algoma Steel Corp., and at Richard Thomas & Co.

I Wish . . .

to enter one year's subscription for the IRON AND STEEL ENGINEER at $7.50 per year:

☐ Check enclosed

☐ Bill me later

I desire information on membership in the Association of Iron and Steel Engineers:

☐ Application blank

☐ Data

Name_____

Title_____

Company_____

Mailing Address_____

Mail this coupon to:

Association of Iron and Steel Engineers
1010 Empire Building
Pittsburgh 22, Penna.

Call or Write STAMCO for...

Corrugating and Complete Line of Culvert Equipment—Slitting and Coiling Equipment for Ferrous and Non-Ferrous Material in All Capacities—Warehouse and Steel Mill Cut to Length Lines for Shearing and Levelling Sheets from Coils—Shears for Shearing Sheets and Plates Both Underdriven and Overdriven Types in all Capacities up to 1¼" plate.

STAMCO, Inc., New Bremen, Ohio

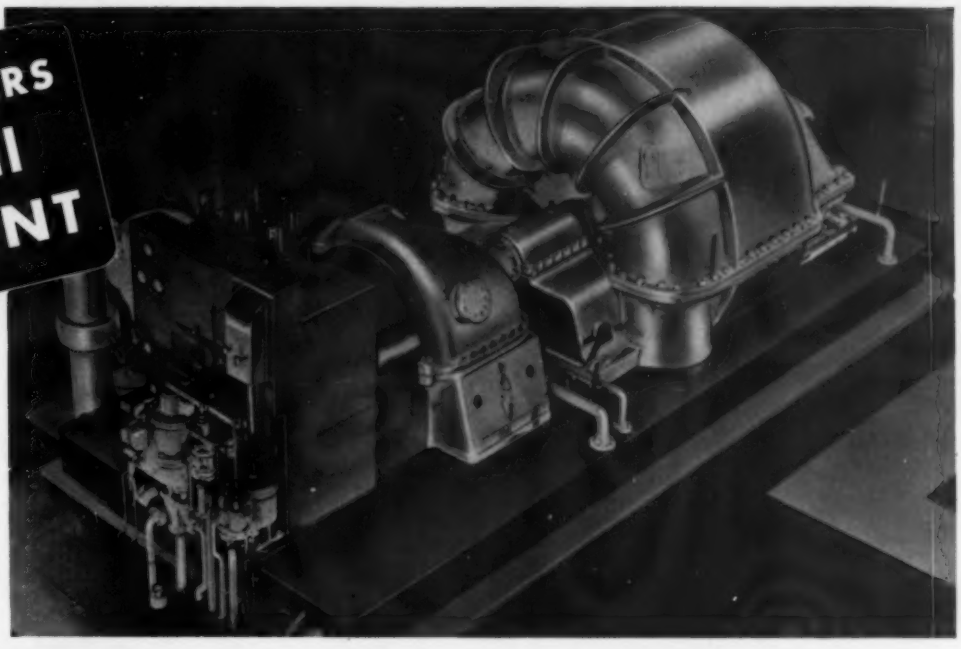
on-the-spot-cooling for CRANE CABS • PULPITS • HEAT RELIEF ROOMS

LINTERN
AIRE-RECTIFIERS

Larco. inc.
ROUTE 20, EAST PAINESVILLE, OHIO
Distributors of Lintern Corporation products

Top Efficiency Compressors For *ANY* Steel Mill Duty

ALLIS-CHALMERS Steel Mill EQUIPMENT



Blast Furnace Blowers — Allis-Chalmers manufactures a complete line of centrifugal units for blast furnaces. The 75,000-cfm, 30-psig blower shown at right, placed in operation in 1942, is driven by an Allis-Chalmers 8500-hp steam turbine.

Allis-Chalmers also builds a wide range of axial compressors for high efficiency blast furnace duty. Axial compressors are smaller, easier to install — require less floor space.

Plant Air Supply — Two-stage *Ro-Flo* compressor delivers plant air supply with constant efficiency; cuts maintenance requirements. If wear occurs, it automatically compensates for itself so that air supply is unaffected.

From Blast Furnace to Plant Air, Allis-Chalmers Compressors Give High Efficiency at Lowest Installation and Operating Costs

Coke Oven Blowers — Allis-Chalmers centrifugal types are recommended for booster, exhauster, or combination booster-exhauster service. Photograph shows four 23,000-cfm, 5100-rpm, 3.5-psig exhausting blowers in a western steel mill.

Allis-Chalmers has had wide experience building and applying compressors of all sizes and types. For help with your air and gas handling problems, call the A-C office in your district, or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin.

A-4865

Ro-Flo is an Allis-Chalmers trademark.

ALLIS-CHALMERS

IN JAPAN

NEW Bliss reversing mill doubles in sheet steel and tin plate

This new four-high reversing mill at Yodogawa Steel Works is another example of how Bliss can engineer equipment to meet a special operating need. This ability...and the policy from which it stems... are important reasons why Bliss has grown to be a leading builder of rolling mills and mill equipment in little more than a quarter of a century.

Dual roll coolant systems make it possible for Yodogawa to roll either steel sheet or tin plate. The two systems provide a quick, easy change-over from the water soluble oil solution needed for sheet products to palm oil for tin plate products.

The mill itself is a 16″ and 53″ by 54″ capable of rolling strip up to 48″ in width at a maximum speed of 2012 feet per minute. The tension reels of its coil handling equipment can accommodate 20″ I.D. by 56″ O.D. coils weighing 30,000 pounds. The work rolls are alloy forged steel, while the backing rolls are Technalloy steel cast by Bliss' Mackintosh-Hemphill Division.

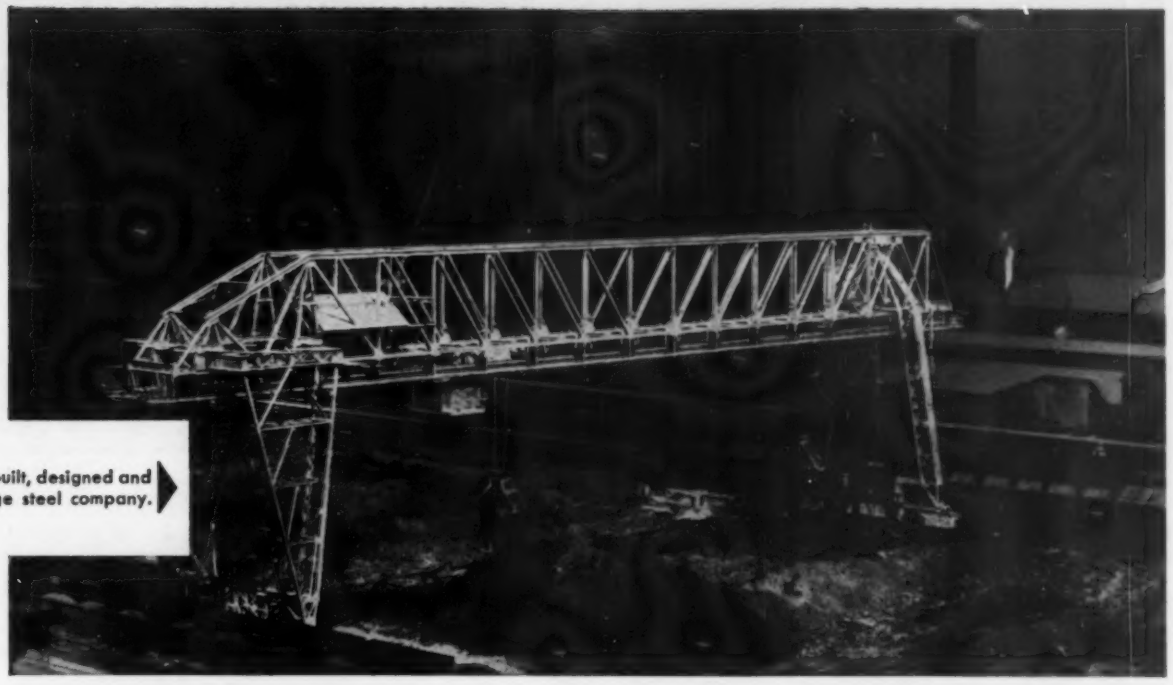
To gain an idea of what Bliss can do to help solve your particular rolling problem, write us today for a free copy of our 60-page Rolling Mill Brochure, Catalog 40-A.

E. W. BLISS COMPANY
General Office: Canton, Ohio
ROLLING MILL DIVISION
SALEM, OHIO

PLANTS: Canton, Cleveland, Salem and Toledo, Ohio; Detroit and Hastings, Michigan; Pittsburgh and Midland, Pennsylvania; San Jose, California. In Europe: E. W. Bliss (England) Ltd., Derby; E. W. Bliss Co. (Paris), France.

BLISS
SINCE 1857

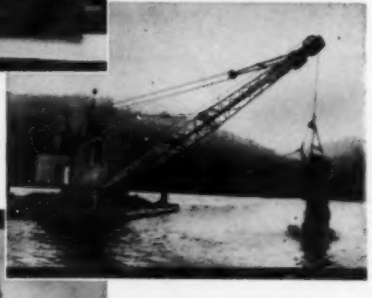
is more than a name... it's a guarantee



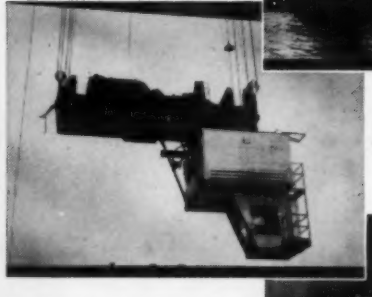
12-ton ore bridge, built, designed and installed for a large steel company.

DRAVO HEAVY MATERIALS-HANDLING EQUIPMENT ...CUSTOM BUILT FOR YOU!

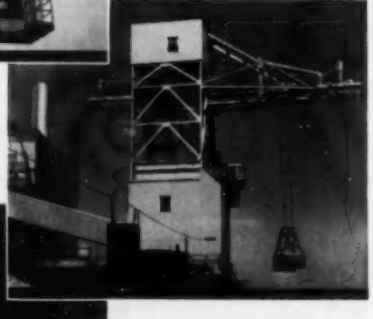
Travelling unloading towers built to handle imported iron ore at an Atlantic port.



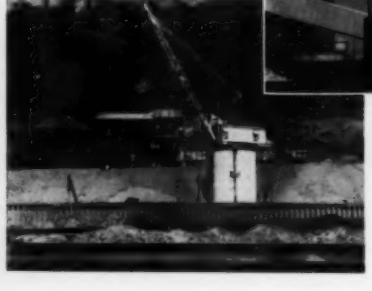
Whirler crane mounted on pontoon hull is used for dredging and general contract work.



Light-weight man trolley installation increased bridge handling capacity 60%.



Coal unloader designed and built for a large mid-western electric power company.



Stationary whirler crane designed and built to transfer coal from barges to hopper cars.

Over-all economical and safe performance is best obtained by using materials-handling equipment designed to suit your operating conditions. If you're planning a new materials-handling installation, we suggest an early "Round Table" session with Dravo engineers.

From actual experience over the past 60 years in building and installing the equipment shown here, valuable data is available in working out the features you want in your installation. This information, along with your own operating experience, can be used to create a design incorporating all the best features for easy maintenance, a high safety factor and simple, economical and satisfactory operation.

You can profit by taking advantage of this specialized "Round Table" service.

DRAVO

CORPORATION

NEVILLE ISLAND, PITTSBURGH 25, PENNSYLVANIA

AIR CONDITIONING • BOILER AND POWER PLANTS
CRANE CAB COOLERS • DOCKS • INDUSTRIAL FOUNDATIONS
OPEN STEEL FLOORING • PUMP HOUSES AND INTAKES
SPACE HEATERS • WATER AND WASTE TREATMENT PLANTS
TOWBOATS AND BARGES

How Well Does Your Present Source Compare With National's COMPLETE Facilities For Motor and Generator Repair

Most motor repair shops can perform some of the operations listed below. Very few can handle them all. These are not routine operations, but extras which require expensive specialized equipment and experience. National service includes all 17 operations. How does your present repair source compare?

plus value operation	*available at National*	*at your present repair source*
1. redesigning and modernizing by competent engineers	yes	
2. vapor degreasing to insure good bonding of varnish	yes	
3. corncob blasting to prepare surfaces like new	yes	
4. rebuilding and remachining to standard of mechanical fits	yes	
5. temporary hotbanding to seat coils in slots	yes	
6. hot rerolling of permanent bands	yes	
7. grinding and polishing of journal shafts	yes	
8. vacuum impregnating	yes	
9. dynamic balancing	yes	
10. grinding and polishing of commutator at top operating speed	yes	
11. load testing	yes	
12. high frequency testing	yes	
13. electronic bar-to-bar and high sensitivity ductor testing	yes	
14. surge comparison testing	yes	
15. high potential ground testing	yes	
16. magniflux testing	yes	
17. anti-friction bearing inspection	yes	
Total	17	

If you can't answer "yes" for your present source on all 17 operations, you're taking unnecessary chances on getting less than the best repair work. You can't tell in advance on which jobs National equipment and National know-how will pay off in improved performance or longer life. So play it the one safe way — make National your first source for *all* motor and generator repairs.

For more details on why the motor or generator you send to National will often come back better than new, call your nearby National field engineer today. Or drop us a line for his name and address.

NATIONAL ELECTRIC COIL COMPANY

COLUMBUS 16, OHIO, U. S. A. TRADE MARK

ELECTRICAL ENGINEERS: MAKERS OF ELECTRICAL COILS AND INSULATION
REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

IT'S TAPER-LOCK! IT'S ALL STEEL!

PATENTED FULL-DEPTH WELD GIVES 100% STRENGTH

Modern! Superior! Taper-Lock Steel Conveyor Pulleys have terrific impact capability. All welds are made by the submerged arc process for 100% strength. Taper-Lock's patented back-up bar permits a weld of full rim thickness. Diameters 6 inches to 8 feet, all face widths. Popular sizes stocked by Dodge Distributors. Write us for data.

DODGE MANUFACTURING CORPORATION, 5900 Union St., Mishawaka, Ind.

DODGE

of Mishawaka, Ind.

THE ELECTRIC FURNACE CO. Salem, Ohio.

EF

Gas Fired, Oil Fired and Electric Furnaces.

HEAT PROCESSING FURNACES

for the Steel Industry

Equipment for annealing, normalizing, galvanizing and other heat processing of high and low carbon steel, stainless, silicon and other alloys—strip, sheet, wire, tubing and other ferrous and non-ferrous products.

Submit your problems to EF engineers

See our advertisements in preceding and following issues

THE ELECTRIC FURNACE CO.

Salem - Ohio

GAS-FIRED, OIL-FIRED AND ELECTRIC FURNACES FOR ANY PROCESS, PRODUCT OR PRODUCTION

---

at last . . . the solution to

really tough gas-cleaning problems

Sub-micron fumes are the *really tough* problems in gas cleaning. These fumes cannot be economically or effectively controlled by conventional cleaning devices.

However, the CHEMICO P-A VENTURI SCRUBBER is proving its success in solving these *really tough* problems in more than 150 commercial installations and in more than 70 pilot investigations.

The table lists some of these commercial installations. All of these *really tough* problems and many more are being solved with complete satisfaction to users of P-A VENTURI SCRUBBERS.

PROCESS	DUST OR FUME	INSTALLED CAPACITY CFM
Incinerator—Flue Fed	Fly Ash	32,000
Incinerator—Sodium Disposal	Na_2O	9,000
Incinerator—Industrial	Radioactive Dust	6,000
Dry Ice & CO_2 Plants	Amine Recovery	72,400
CO_2 Gas for Process	Fly Ash	500
Boiler Flue Gas	Fly Ash & SO_2	4,300
Enamel Frit Furnace	Dust & HF	11,900
H_2SO_4 Concentrator	H_2SO_4	49,800
Copperas Roasting	H_2SO_4	34,250
Cobalt Ore Roasting	H_2SO_4	65,000
Chemico Wet Type Acid Plant	H_2SO_4	41,000
Chloro-Sulfonic Plant	H_2SO_4	600
Phosphoric Acid Plant	H_3PO_4	91,900
Phosphoric Acid Concentrator	H_3PO_4	194,000
Phosphor Copper Furnace	H_3PO_4	15,000
Smelting—Non-Ferrous		
Blast Furnace	Lead & Organic	12,000
Reverb. Furnace	Lead Compounds	23,500
Comb. Blast & Reverb.	Lead Compounds	7,000
Brass Furnace	Zinc Oxide	7,500
Ajax Furnace	Beryllium Fumes	4,000
Steel Plant		
Oxygen Steel Process	Iron Oxide	140,000
Blast Furnace	Coke & Iron Oxides	788,000
Zinc Sintering	Zinc Oxide	75,000
Wood Distillation	Tar Products	3,500
Na_2SiF_6 Dryer	SiF_4 & Dusts	700
Iron Chloride Concentrator	$FeCl_2$ & HCL Mist	40,000
Unknown	Carbon Black	1,700
Lime Kiln	Lime & Na_2O	18,000
Detergent Spray Dryer	Chemical Fume	250,000
Furfural Residue Burner	Fly Ash	36,000
Nodulizing Kiln	Manganese & Lead	25,000
Aluminum Pot Lines	Tar Fog, Fluorides	40,000
Carbide Furnace	Metal Oxides	1,000
Asphalt Plant	Rock Dust	80,000

Write to our P-A Sales Department for Bulletins

P-A VENTURI SCRUBBERS

(PEASE-ANTHONY)

CHEMICAL CONSTRUCTION CORPORATION

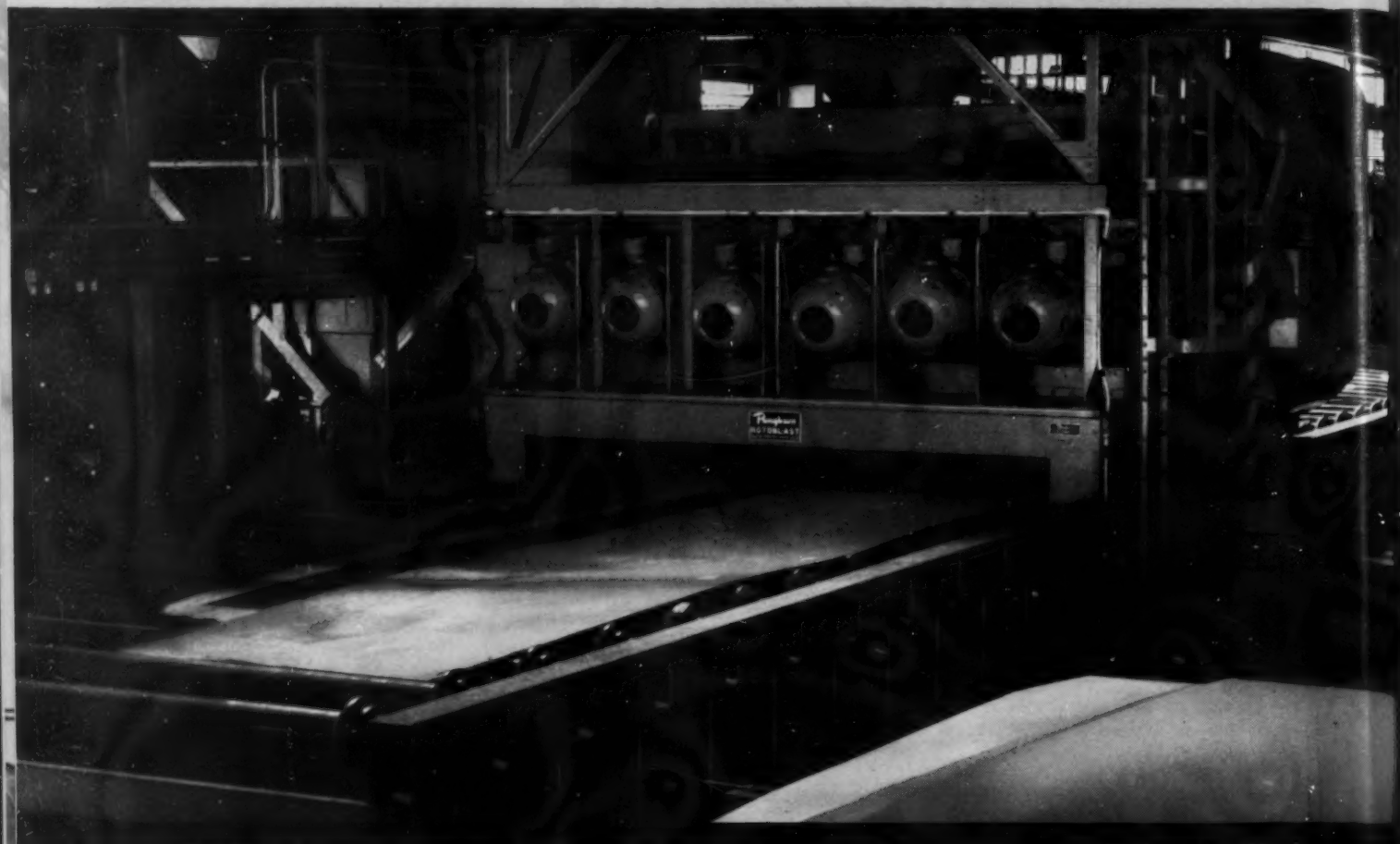
525 WEST 43RD STREET, NEW YORK 36, N. Y.

Telephone LOngacre 4-9400

Technical Representatives Throughout the World

Cable Address: CHEMICONST, N. Y. CC-306

Descale steel sheets, plates, coils



at *less than half the cost*

No more scale breaking or pickling! No more acid disposal problems! Pangborn Rotoblast Descaling Machines descale steel sheets, plates and coils, and they operate at big savings over pickling costs!

How? They work quickly. They clean thoroughly. They're a one-man operation. Unlike acid baths, they can be located near your production, cutting handling costs. And they save floor space, require much less room than vats. Available in a variety of models, Pangborn Rotoblast Descaling Machines handle steel sheets, plates and coils of any thickness, width and length. If you want to cut descaling costs to the bone, investigate Pangborn Descaling Machines!

For complete information, send for Bulletin 224. Write: PANGBORN CORPORATION, 4400 Pangborn Blvd., Hagerstown, Maryland.

*U. S. Pat. #2184926 (other patents pending)

with Pangborn Rotoblast® Descaling Machines!

Pangborn

1 PS

BLAST CLEANS CHEAPER

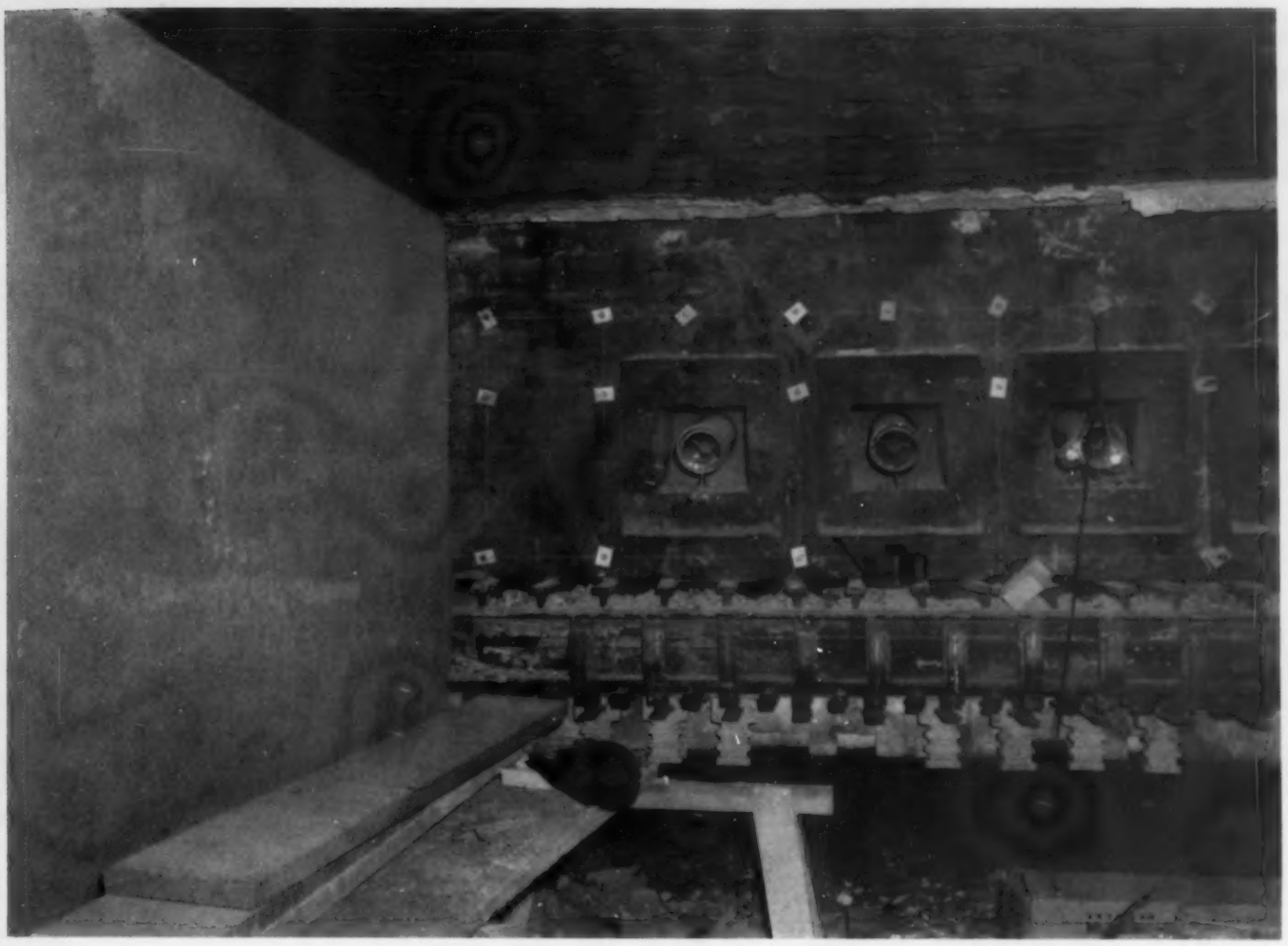
Rotoblast Blastmaster® & Continuous-Flo Barrel

Rotoblast Tables & Table-Rooms

Special Blast Rooms & Cabinets

Pangborn Dust Control Equipment

Malleabrasive® Shot & Grit



Ramtite® Lined Fifty Ton Slab Heating Furnace

Heats 700 Tons in One Turn at Alan Wood Steel Co.

AGAIN—a Ramtite lined triple fired slab heating furnace incrases steel production and reduces refractory maintenance cost. Increased production with Ramtite roof and walls is partially due to the insulating value of Ramtite monolithic construction.

As soon as preparations are completed to take advantage of the greater furnace width made possible by Ramtite thin walls, longer slabs will be heated, and a further increase in steel production will result. Can you afford not to use Ramtite?

Manufacturers of: PLASTIC — CASTABLE — GUNNING REFRACTORIES

RAMTITE IS OUR BUSINESS . . . . NOT A SIDE LINE

The Ramtite Co.
DIV. OF THE S. OBERMAYER CO.

THE RAMTITE CO., Div. of The S. Obermayer Co.
1813 South Rockwell St., Chicago 9, Ill.

Please send items checked

- ☐ Bulletin on Castable and Gunning Refractories
- ☐ Steel Plant Bulletin

Company Name_____

Attn. Mr._____ Title_____

Address_____

City_____ Zone____ State_____

© 1956

Keystone Aluminum Conductor System Installed at Penna. R.R. Shops

ASSURE 7 WAY SAVING IN WEIGHT...POWER...LABOR

THIS IS AN immense project—the new car repair shop of the Pennsylvania Railroad. The shop is 2760 ft. long; 15 overhead cranes are required with capacities up to 25 tons. To furnish electrical connections for the cranes two 3-rail Keystone Aluminum Conductor Systems, each running the full length of the shop, were specified and installed.

Keystone was judged best qualified to meet the rigid conditions required of this installation. It was selected because it would . . .

SAVE TRANSFORMERS—Three installations needed with steel conductors are eliminated with Keystone Aluminum Conductor System.

SAVE FEEDER RUNS—With this non-magnetic system, all but the center tap is eliminated.

SAVE BOOSTER CABLES—System capacity permits satisfactory operation ¼-mile from feeder without boosters.

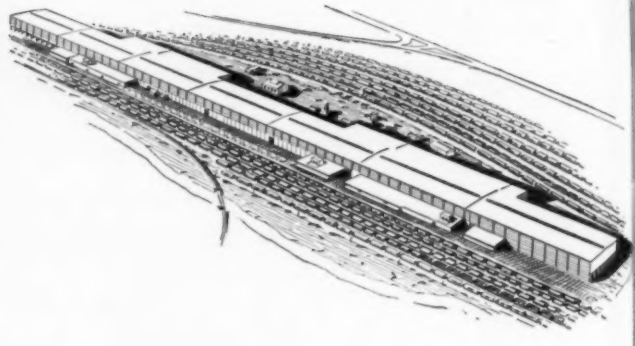
SAVE CAPACITY—Compact design permits close conductor spacings, minimizing impedence drop, reducing conductor size.

SAVE ENGINEERING COSTS—Integrated package design, factory assistance reduce time and effort.

SAVE INSTALLATION COSTS—Lightweight components, factory prefabrication, foolproof design cut erection time and cost.

SAVE OPERATING COSTS—Adequate voltage supply assures maximum crane operating speeds, reduces motor overloads. Protected contact surfaces eliminates shutdowns on exposed systems.

Keystone Aluminum Systems are now operating countrywide on AC and DC runways from 50 to 2760 ft. long, and on ore bridges and unloaders. Standard components range from 500 to 1000, 2000, 3000 and 6000 amp. capacity. Write today for case histories—*"Solving Conductor Problems."*



NEW SAMUEL REA SHOP at Hollidaysburg, Pa. where 50 steel hopper and gondola cars will be rebuilt each day. Large photo above shows 5 of the 15 overhead cranes, 2760-ft. runway; insert shows close-up of Keystone three-rail collector assembly. The Harry F. Ortlip Company of Philadelphia, specialists in railroad engineering and one of the largest electrical construction firms in the East, made the installation for Pennsylvania Railroad.

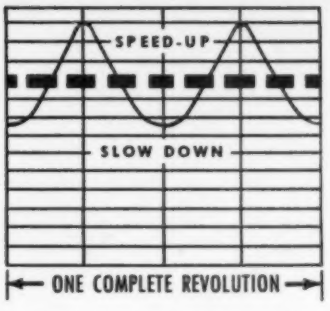
ELECTRIC SERVICE MANUFACTURING CO., PHILADELPHIA 32, PA.

KEYSTONE

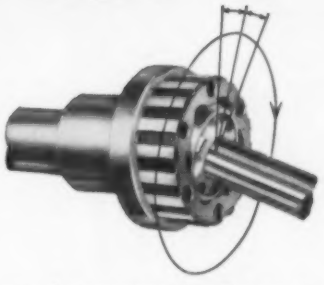
FACTS...

on a Universal Joint that cuts costs, increases production in steel-making equipment

During rotation at a given angle, pin- or slipper-type joint speeds up, slows down twice during one revolution.



Solid line shows speed variation for one revolution of pin- or slipper-type joint at a critical angle. Note constant velocity of 100% for Rzeppa Joint (dotted line).



Due to its construction features, the Rzeppa Joint always transmits a smooth flow of power even at unbalanced angles. The standard joint cannot meet this test without involved compensating measures.

IN THESE TYPICAL APPLICATIONS

Among the many applications where Rzeppa Constant Velocity Universal Joints are ideally suited are:

- Blooming Mills
- Billet Mills
- Merchant Mills
- Skelp Mills
- Butt Weld Pipe Mills
- Electric Weld Tube Mills
- Hot Strip Mills
- Cold Reduction Mills
- Auxiliary Equipment

The above facts prove why you can expect superior performance when your steel-making equipment utilizes Rzeppa Constant Velocity Universal Joints. Rzeppa's *modern design* offers you all these advantages:

- INCREASED SPEEDS
- REDUCED DOWN-TIME
- LOWER MAINTENANCE
- HIGHER CAPACITIES

The next time you are considering universal joints for replacement or original equipment—why not look into the exclusive features offered only by Rzeppa.

WRITE TODAY . . . for this complete brochure which offers you many more FACTS on Rzeppa Constant Velocity Universal Joints.

RZEPPA

("SHEPPA")
CONSTANT VELOCITY UNIVERSAL JOINTS

THE GEAR GRINDING MACHINE COMPANY
3929 CHRISTOPHER, DETROIT 11, MICHIGAN
Manufacturers of: Fully Automatic Gear Grinding Machines • THE DETROIT SCREWMATIC 750

ENGINEERING . . . FABRICATION . . . AND ERECTION BY *Pollock*

The William B. Pollock Company is the oldest engineer, fabricator and erector of steel work for blast furnaces in the world

Only a few companies in the world can engineer, fabricate and erect the steel work for a complete blast furnace, and The William B. Pollock Company is one of them. Over the years Pollock has erected more blast furnaces than anyone in the world. We're specialists in heavy steel work, fully equipped to engineer and fabricate plate and structural requirements and do heavy machine work on castings and weldments.

Pollock engineers are at your service. Use them. They'll analyze your needs and suggest the most practical, efficient and economical solutions.

POLLOCK
Since 1863

The William B. Pollock Co.

YOUNGSTOWN, OHIO

Engineers • Fabricators • Erectors
Steel Plate Construction

BLAST FURNACES • HOT METAL CARS AND LADLES
CINDER AND SLAG CARS • INGOT MOULD CARS
CHARGING BOX CARS • WELDED OPEN HEARTH LADLES

Lapointe Machine Tool Company, Hudson, Massachusetts

FIRST OF ITS KIND IN THE WORLD!

...And It's Lubricated by Cities Service Pacemaker 400 T Oil!

LAPOINTE MACHINE TOOL COMPANY, originator of the broaching method of cutting metal over 50 years ago, has now originated the first vertical broaching machine with variable speed electro-mechanical drive.

Purpose of the huge, gear-driven machine is to increase tool life up to 500% through smoother operation, thus saving down time and producing more accurate work.

Selection of a lubricant for the new machine was of special importance because of the tremendous pressures it develops: normally 30,000 pounds, sometimes up to 60,000 pounds. Of the many brands of lubricants Lapointe tested, Cities Service Pacemaker 400 T had the necessary requirements for the job . . . so naturally, this superior lubricant got the job.

"We test the machines with Pacemaker 400 T at the factory and then put it in again when the broaches are assembled at the buyer's plant," says Lapointe. "It offers all the characteristics we need: Good film strength, high viscosity index, and exceptional anti-foam and anti-oxidant qualities. Needless to say, we're pleased and impressed with this Cities Service lubricant."

Like scores of others, Lapointe has discovered the search for a proper lubricant ends at the Cities Service label. Altogether, there are hundreds of Cities Service products for the exacting needs of industry. For more information, talk with your nearby Cities Service Lubrication Engineer. Or write: Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.

Quick Facts About New Broaching Machine

USES: Now used for broaching aircraft engine turbine buckets, but can be adapted to general broaching.

ADVANTAGES: Increases tool life 400-500% through smoother operation, less down time. Produces more accurate work. Variable cutting speed: 12 to 75 FPM. Available in single or double ram models with 72″ to 100″ stroke.

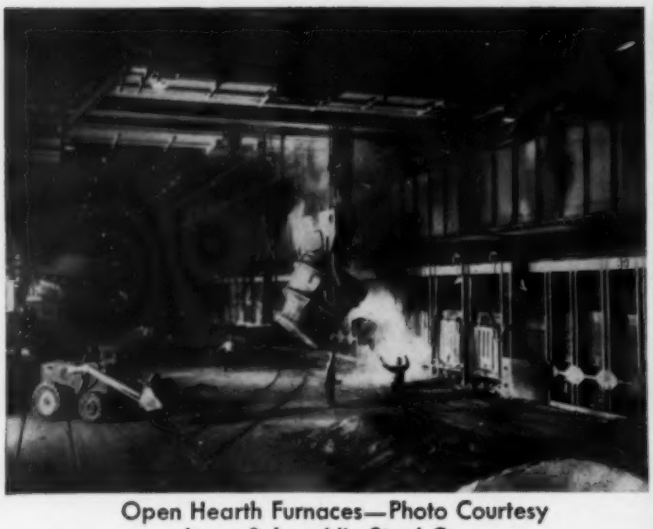
Quick Facts About Pacemaker 400 T Oil

USES: Propulsion turbine units where oil is circulated under heavy pressure. Widely used in naval and commercial vessels, high speed industrial machinery.

ADVANTAGES: High viscosity index, excellent heat resistance and film strength. Chemically fortified against oxidation, rust, and foaming.

CITIES SERVICE

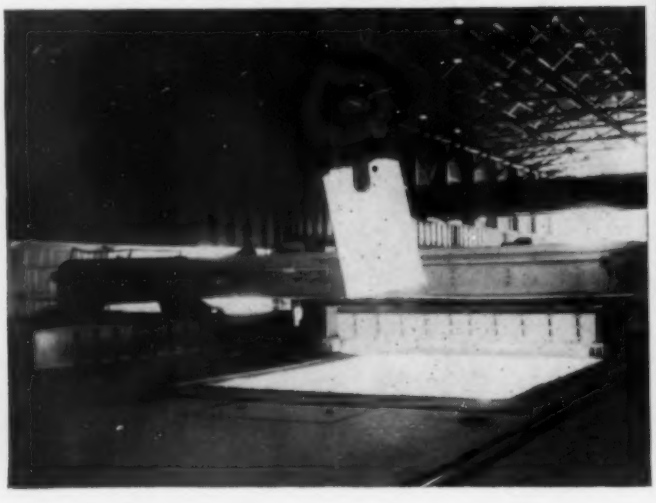
QUALITY PETROLEUM PRODUCTS



Open Hearth Furnaces—Photo Courtesy
Jones & Laughlin Steel Corp.

Continuous Heating Furnaces—
Photo Courtesy Crucible Steel Co.

Soaking Pit—Photo Courtesy
United States Steel Corp.



Heat Treating Furnace—
Photo Courtesy Taylor Forge & Pipe Works

Increase Production . . . Lower Production Costs with

LOFTUS Industrial FURNACES

For years Loftus Industrial Furnaces have been providing dependable, economical service to the steel industry. Their long life and efficient performance have been proved by time. The fact that they materially contribute to lower-cost operation and increased production is a matter of record.

Whatever your heating or heat-treating requirements, it will pay you to take advantage of Loftus' long experience in furnace design and construction. Many of the world's leading companies have—and to their utmost satisfaction, as proved by the high percentage of repeat orders we get.

We would welcome an opportunity to quote on your requirements.

Designers and builders of industrial furnaces

LOFTUS
Engineering Corporation

610 Smithfield Street, Pittsburgh 22, Pa.

For the Maximum in Dust Recovery...

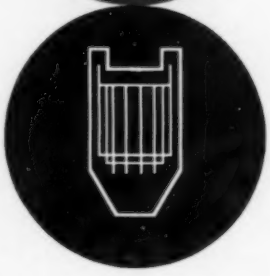
... an unbiased recommendation from

WESTERN PRECIPITATION

The only organization with 48 years of dust collection experience.

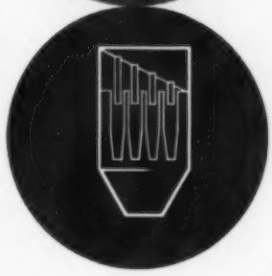
ELECTRICAL, MECHANICAL *and* FILTER *types of recovery systems.*

COTTRELL
Electrical
PRECIPITATORS



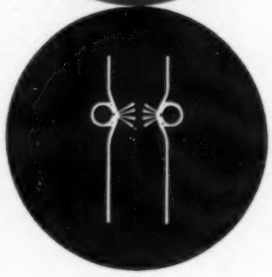
Western Precipitation pioneered commercial application of the now-famous Cottrell **Electrical** Precipitator—has more know-how, more experience, more basic advancements in this highly-technical electrostatic field of recovery than any other organization, domestic or foreign.

MULTICLONE
Mechanical
COLLECTORS



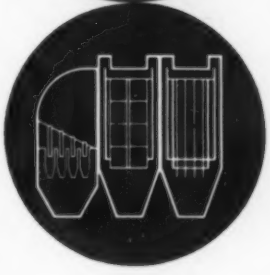
Western Precipitation pioneered the multiple tube type of cyclonic collector—the type with higher centrifugal forces for greater recovery efficiencies. Multiclones are also easier to install, service and maintain—and require less space than other equipment of comparable capacity.

DUALAIRE
Reverse Jet
COLLECTORS



This is the filter-type recovery unit that continuously and automatically maintains filter porosity with virtually the entire filter area in service as it filters the gas. Cleans without jarring or rapping... pressure drop remains uniformly low, filter capacity remains uniformly high because no thick filter cake ever forms to reduce effectiveness. Actual field tests show collection efficiencies higher than 99.99%.

ALSO...
Combination
SYSTEMS



A Combination Multiclone and Precipitator (CMP), for example, combines in one compact unit the advantages of the Multiclone for removing the heavier particles (down to a few microns in size) and the advantages of the Precipitator for final clean-up. Result—high overall recovery efficiency at very nominal overall cost—almost constant collection efficiency despite varying gas volume.

Let us send you literature which describes Western Precipitation's unique services in greater detail. Write, wire or phone our office nearest you!

wp

COTTRELL Electrical Precipitators
MULTICLONE Mechanical Collectors
CMP Combination Units
DUALAIRE Reverse-Jet Filters
HOLO-FLITE Processors

Western Precipitation Corporation

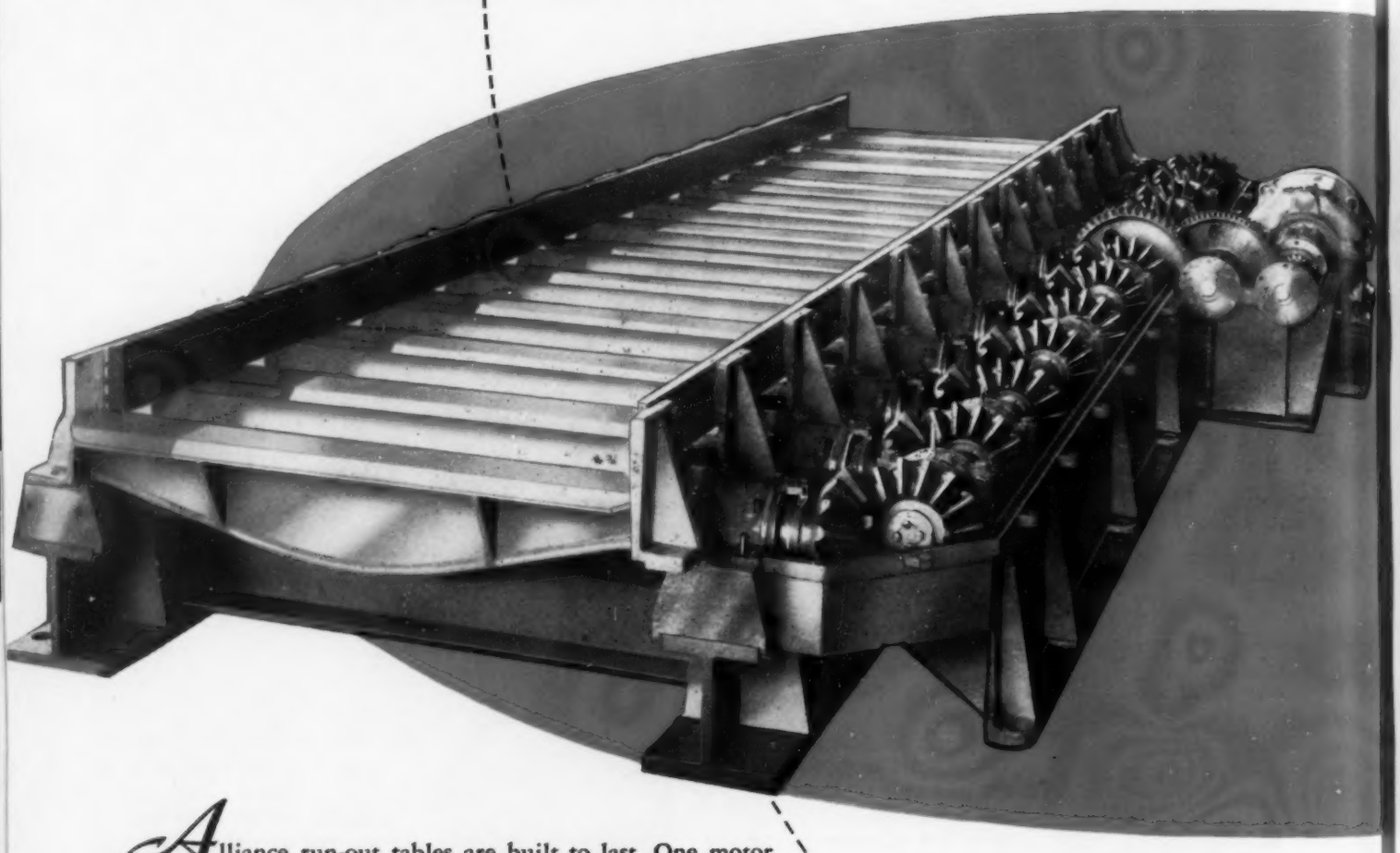
Designers and Manufacturers of Equipment for Collection of Suspended Materials from Gases and Liquids

Main Offices: **1067 WEST NINTH STREET, LOS ANGELES 15, CALIFORNIA**

Chrysler Bldg., New York 17 • 1 North La Salle Street Bldg., Chicago 2 • Oliver Bldg., Pittsburgh 22 • 3252 Peachtree Rd. N. E., Atlanta 5 • Hobart Bldg., San Francisco 4 • Precipitation Co. of Canada Ltd., Dominion Sq. Bldg., Montreal

Alliance RUN-OUT TABLES

Designed* to last...
THE LIFETIME OF YOUR MILL



Alliance run-out tables are built to last. One motor drives all rollers, turning them at the same speed. This reduces slippage and assures smooth handling of ingots, blooms and slabs. The gears (shown exposed) driving each roll are totally enclosed and run in oil. A sealed cover keeps lubricant in and dirt out.

Alliance designed and built this trouble-free run-out table to operate efficiently for the lifetime of a mill. Depend upon Alliance to build the best.

Send your heavy equipment requirements to "the world's largest builders of the world's largest cranes".

*** LINK DRIVE ROLLERS**

Uniform roller drive on the new Alliance run-out table moves steel more smoothly and keeps friction to a minimum, lengthening the table's service life.

"Give us the Runway and we'll lift the World"

THE Alliance MACHINE COMPANY

FOUNDED 1901

MAIN OFFICE ALLIANCE, OHIO

World's largest builders of world's largest cranes

Manufacturers of:

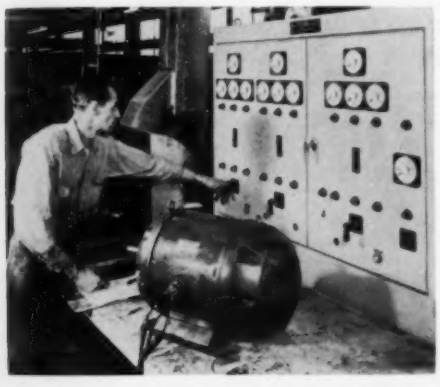
LADLE CRANES • GANTRY CRANES • FORGING MANIPULATORS • SOAKING PIT CRANES • STRIPPER CRANES • SLAB AND BILLET CHARGING MACHINES • OPEN HEARTH CHARGING MACHINES • SPECIAL MILL MACHINERY • STRUCTURAL FABRICATION • COKE PUSHERS • ORE BRIDGES • SHEET CARRIERS

Equipment News...

MOTOR REPAIR

▲ A new semiautomated production line has cut repair time of electric motors over 50 per cent at the General Electric Co.'s Chicago Apparatus Service Shop.

Motors up through 50 hp can now be diagnosed, disassembled, cleaned, rewired, rebuilt, tested, and ready for delivery in 8 hours. This faster time



All three motor leads are connected at the same time for three simultaneous but separate checks by this General Electric motor testing equipment at the company's Chicago Apparatus Service Shop. When the operator has made a running test, phase balance, and high potential check, the a-c motor will have been diagnosed, disassembled, cleaned, rewired, rebuilt, tested, and ready for delivery in 8 hours.

compares with about 19 hours normally required for complete motor service.

Representing the first time a motor repair production line has used a completely automatic baking oven, the integrated system has conveyor lines throughout.

Disabled motors that follow the routine of this integrated production line, undergo disassembly, inspection, cleaning, roasting, sandblasting, winding, dipping, baking, moisture treatment, reassembly, painting, and testing within an 8 hour period.

ALUMINIZED FIRESUIT

▲ A suit that enables a man to work in temperatures one-eighth as hot as the sun's surface was demonstrated in New York recently.

The demonstrator six times entered an industrial furnace heated to 1200 F, the highest temperature ever entered publicly for more than a few seconds. He stayed two or three minutes each time as if on a repair or rescue mission.

The demonstation—sponsored by Minnesota Mining and Manufacturing Co.—was held to show the heat-protective qualities of fabrics coated with a thin layer of aluminum, a process developed by Minnesota Mining. The aluminum-coated fabric reflects radiant heat instead of insulating against it.

This permits less bulky insulation, it was explained, so that a man can move and work at temperatures higher than ever before to repair, investigate, inspect, rescue or extinguish.

It was the first public showing of the aluminized fabric used in the suit. The fabric has been undergoing on-the-job evaluation in hundreds of such suits in industrial plants during the past four years, Minnesota Mining said.

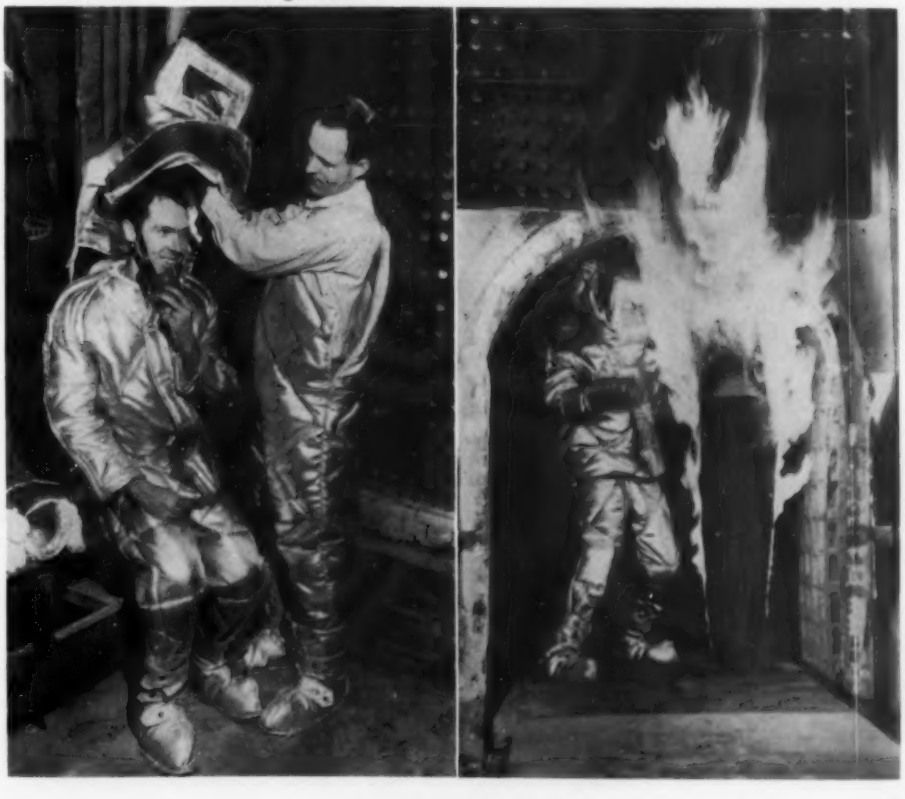
The suit used in the demonstration —produced by Fyrepel Products, Inc.—has the aluminum coating on a fibre glass material which is backed up with fibre glass quilting. It is designed for intense heat.

Advantages of the new fabric are protection from radiant heat; light weight; flexibility, which enables the wearer to work comfortably; and durability.

An eastern steel company reported an incident in which molten slag was showered on two workers wearing long coats made of aluminum-coated asbestos—and the slag rolled off the coats and left the men with only minor burns.

In another instance, a midwest firm reported saving 35,000 man-hours in production time because an aluminized suit permitted an engineer to enter a hot zone immediately and make a ten-minute repair. Otherwise the firm would have had to shut down production for a several-days cooling-off period before the repair could be made, then reheat for several days before resuming production.

An engineer wearing this suit went into the furnace while at a temperature of 1200 F with an armload of wood. He returned unharmed although wood in his arms ignited.



STOOLS

- weighing 10,000 pounds each
- alloyed 25% Cr—12% Ni
- for 1750°F. temperatures

DURALOY

These stools should offer a very pertinent tie-in with your casting requirements. Essentially, they are alloyed to resist heat. They're typical of the heavy high alloy castings we are equipped to turn out.

They will serve also to indicate what we can do in the way of producing castings to resist not only high temperatures but severe corrosion or combinations of heat and corrosion, as well.

Today, we can offer several distinctly different types of castings in the high alloy field including static, centrifugal and shell-molded.

Many in both the metal working and processing fields have come to look upon Duraloy as the leading producer of exclusively high alloy castings. This reputation has been built on many years production of sound castings properly alloyed. We'll be glad to discuss your high alloy casting requirements.

THE DURALOY COMPANY
OFFICE AND PLANT: Scottdale, Pa.
EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.
CHICAGO OFFICE: 332 South Michigan Avenue

MAGNETIC COMPOUND

▲ Scientists of Westinghouse Electric Corp. have perfected a magnetic material that promises to yield more powerful permanent magnets.

Dr. Clarence Zener, acting director of the Westinghouse research laboratories, disclosed that the material is virtually 100 per cent pure manganese-bismuth — a chemical compound that has the formula "MnBi." He described the material as having "significant advantages over existing materials for permanent magnets" and said it is the result of a new and improved method for the preparation of the highly-purified manganese-bismuth in powder form.

So promising are the magnetic properties of the new material that Dr. Zener predicts it may materially affect the future design, construction and performance of many present day devices that employ permanent magnets.

"Perhaps the greatest advantage of MnBi magnets is their unusual resistance to demagnetization," Dr. Zener said. "These magnets are at least 10 times better in this respect than most commercial magnets available today."

This resistance to demagnetization, which comes from a magnetic property called high coercive force, suggests many advantages of MnBi magnets, Dr. Zener declared. Such magnets, he pointed out, would not be adversely affected by external magnetic fields. This would make them especially promising for use in electric meters, where "stray" magnetism from large electrical equipment is likely to be encountered.

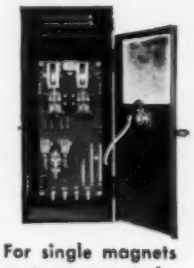
The Westinghouse research executive explained that magnets of manganese-bismuth derive many of their unusual properties from being powder-type magnets. Each individual MnBi particle, about 40 millionths of an inch in diameter, is itself a tiny magnet. The particles are "insulated" from one another by imbedding them in a plastic binder, or matrix, which forms the body of the magnet and keeps the particles separated. Once magnetized, each particle adds to the total magnetism.

"Such 'plastic' magnets offer many advantages," Dr. Zener declared. "Most materials for permanent magnets are notoriously hard to handle. They must be machined to shape

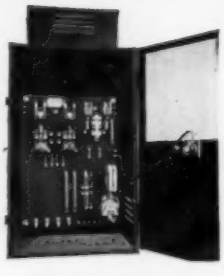
For faster load discharge...low cost operation...longer life...

EC&M Magnet Controllers have earned a reputation for improved magnet operation. Loads are discharged quickly . . . cleanly . . . without "dribble". Magnets "work more" because faster drops eliminate "positioning" the magnet at point of discharge.

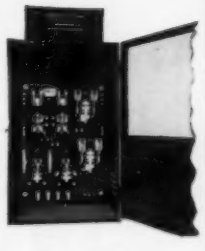
A simple two-position (lift-drop) Master Switch makes operation easy . . . power is off when the master switch is in the drop position. This prevents overheating, keeps lifting capacity high, and substantially adds to magnet life.



For single magnets or two magnets in parallel . . . Type AD STANDARD Controller has exclusive adjustable discharge feature for different type loads. (dial on door).



BOOSTER Controller gives increased pull-away power from pile, then carries load at reduced current.



HIGH SPEED RELEASE DLM-335-A Controller reduces discharge time of deep-type magnets 50%.

EC&M Controllers may be used with all types and makes of magnets.

Write for Bulletin 905

SQUARE D COMPANY
EC&M DIVISION • CLEVELAND 28, OHIO

6169

the case of-- **THE BEARING THAT RESCUED THE AMBULANCE BUILDERS**

BECAUSE a tight production schedule had been maintained--the large, urgent order was nearly completed. Accordingly, the very important customer had been assured that--delivery would be made on time. *Then--a vital bearing in one of the big presses failed.* And, the well-known northern Illinois makers of ambulances and funeral coaches* suddenly found themselves in a serious jam.

How they got out of that jam is told in the letter they later sent to this company--"Just a note to express our gratitude for the top notch service you gave us recently when we were up against it and our press was down. Your cooperation in getting that bearing out to us saved us a lot of time, grief, and money. It certainly is comforting to know we can rely on you to help us out of a tough spot."

This is another example of how closely this company works with its customers. For more than a quarter of a century, giving customers the utmost in service--has been company policy. For instance, in addition to immediate delivery on any type, size, or brand of bearing ordered...expert Bearing Engineering Service is always available ...and...customers can ask for Bearing Surveys any time--ALL for the price of the bearings. Why not phone--NOW?

HYATT

One of the various brands of bearings and specialties regularly carried in stock--for IMMEDIATE DELIVERY

*Name on request

BERRY BEARING COMPANY

All phones--DA nube 6-6800

2633 S. Michigan Ave. Chicago 16, Illinois

SOUTHWEST	OAK PARK	ROCKFORD	HAMMOND	GARY
6923 W. Archer Ave.	327 Madison St.	710 Broadway	4828 Calumet Ave.	716 E. 5th Ave.
LUdlow 5-4400	EUclid 6-1700	Phone: 2-5561	WEstmore 1-3010	TUrner 5-7501

and are extremely hard and brittle. Manganese-bismuth magnets, however, can be easily drilled, tapped, and cut—even with a penknife if a suitable plastic binder is selected."

Dr. Zener also pointed out that because the plastic binder is an electrical insulator, manganese-bismuth magnets are nonconductors of electricity. This, too, suggests new applications for the magnets, he said, since conventional types made of steel or other alloys are all good electrical conductors.

Further work on the new magnetic material has been assigned to the company's materials engineering department, where a program of development is now in progress under the supervision of J. A. Osborn, manager of magnetic materials development.

Mr. Osborn disclosed that the super-pure manganese-bismuth is prepared in this way: Manganese and bismuth are ground together to extremely small size under an inert atmosphere of helium gas. Purpose of the helium atmosphere is to prevent the powdered materials from catching fire spontaneously, which they would do on exposure to oxygen in the air.

The mixture is then sealed in a glass vessel under low-pressure helium. Using precise temperature control, the manganese and bismuth are then caused to unite chemically at a temperature slightly less than 520 degrees F—the melting point of bismuth. The resulting product, virtually 100 per cent pure MnBi, is then reground to a fine powder. These particles are then imbedded in a plastic matrix, oriented in a powerful magnetic field and molded to shape. The new super permanent magnets result.

BAR AND TUBE PRINTER

▲ Developed by The Pannier Corp., is a new offset bar and tube printer that offers speed, simplicity and precision for marking. Code numbers, trademarks, specifications, etc., are printed at speeds up to 200 fpm either by variable speed drive or friction driven from conveyed material.

This printer automatically imprints by friction contact and will accommodate sizes from ½ in. to 14 in. O. D. with only one set of guide rolls. Self contained hydraulic height

Makes Tightest Brickwork Linings in the History of Blast Furnace Construction

Steel mill men report SUPER #3000 Refractory Bonding Mortar Superior to All Others for making dense, tight joints that prevent flow of attacking gases

1. Has but a fraction of the iron content of other refractory bonding mortars, preventing carbon deposition.
2. Does not shrink or spall in the joints; has higher dried density than the brick itself; reduces channeling.
3. Strongest abrasion- and wear-resistant mortar on the market.
4. Has ideal heavy body and water-retention properties for best bricklaying practice on both ceramic and carbon brick.
5. Reduces downtime and maintenance labor and materials; increases productivity.
6. Unlike other mortars, Super #3000 has high bonding strength at low, medium and high temperatures.

REFRACTORY & INSULATION CORP.

R&I

REFRACTORY BONDING AND CASTABLE CEMENTS
INSULATING BLOCK, BLANKETS AND CEMENTS

136 WALL STREET • NEW YORK 5, N. Y.

adjustment completely simplifies adjustments to any size.

One of the features of this new machine is that setup or change-over time for various sizes, colors, and markings are kept to an absolute minimum by simple adjustments and quickly interchangeable components.

This printer will clearly mark all types of rigid or semi-rigid materials, such as steel, iron, aluminum, nickel, stainless, plastic, wood, rubber (hose), etc.

This machine is 39 in. long, 34 in. wide, 41¼ in. high.

REDUCERS

▲ Motorized reducers that combine the advantages of integral motor-reducer units with separately mounted motors have been developed by Foote Bros. Gear and Machine Corp.

These reducers are equipped with a specially designed motor support—the reducer base supports both reducer and motor for easy set-up and shaft alignment. Motor mounting bracket slots are standardized to suit all NEMA motors. These reducers are available in horizontal models for foot mounting or in vertical and vertical extended housing models for flange mounting.

Capacity of these reducers range from 1 to 75 hp for any A. G. M. A. service classification. Double, triple or quadruple reductions provide a selection of ratios from 5.06:1 to 238:1. With these drives, smaller stocks of standard motors are practical, motor change is faster and drive systems are more versatile.

TURBOBLOWERS

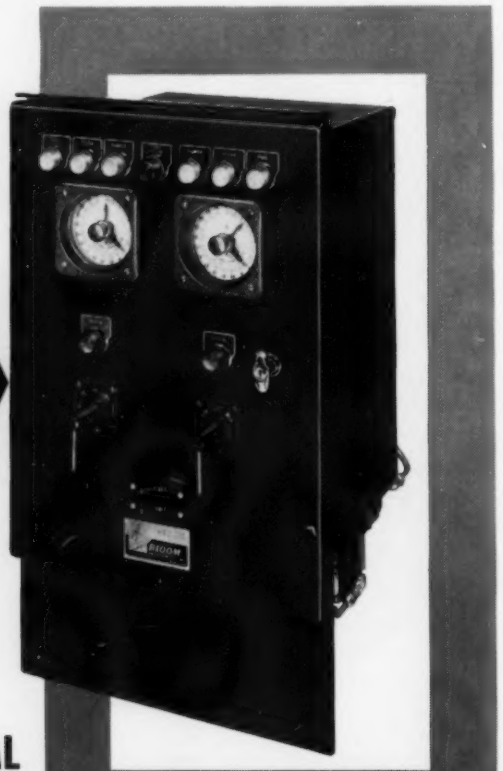
▲ A new line of turboblowers for supplying air to gas and oil burners has been placed on the market by Hauck Manufacturing Co.

These blowers produce constant, dependable air pressure throughout their broad range of volume without pulsation, surgings or vibration. Their flat pressure performance curve makes them particularly desirable for air-fuel proportioning burners. Moderate in first cost, they are also economical in power consumption, and ideal for 24-hour a day operation over extended periods.

The blower is equipped with a sturdy aluminum impeller and hub in a perfectly balanced impeller assembly. Blower casing is of fabricated steel with spun steel head having circular reinforcing rings. It is driven by a standard open frame ball bearing motor. The discharge position on direct motor-driven blowers can be rotated in the field to suit connection conditions. A flexible connecting sleeve with clamps is included.

The blowers are made in a large number of sizes from 250 cfm at 8 oz. pressure to 2650 cfm at 24 oz. pressure.

The BLOOM Time-Cycle Reversal Unit assures FULL, FAST AND EFFICIENT REVERSAL OF REGENERATIVE FURNACES AUTOMATICALLY



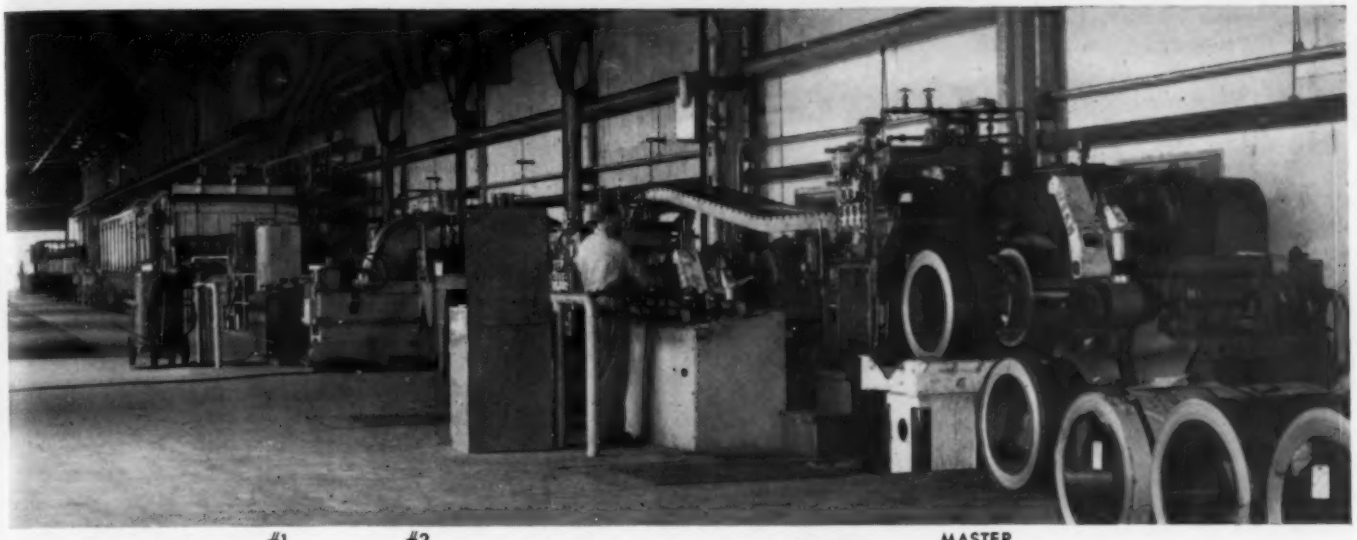
This complete, compact, factory-tested unit provides a combination electric-pneumatic system for Open Hearth Furnace and Soaking Pit reversal. It eliminates reversal puffing and shortens reversal period. (10 to 15 seconds easily accomplished).

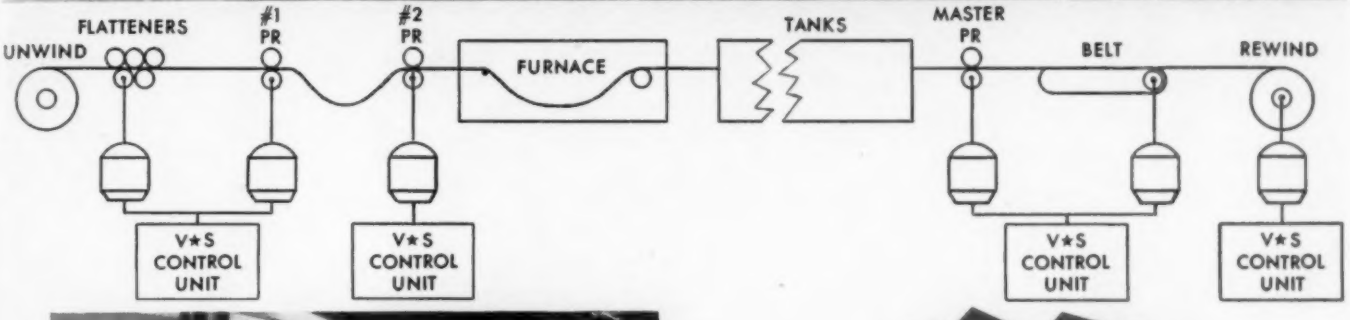
Shorter reversal cycle improves furnace life.

These units have been in continuous service for nine years. Trouble-free maintenance.

BLOOM ENGINEERING CO., INC.
857 W. North Avenue Pittsburgh 33, Pa.

WRITE or phone for complete information on the Bloom Time-Cycle Reversal Unit.





Pickling Line V★S Drive Control Units

RELIANCE V★S DRIVE®

PACKAGED DRIVES KEEP STAINLESS ON THE MOVE

As much as 14 miles of stainless steel strip is processed each day on the Atlas Steels, Ltd. two-strand pickling line . . . Canada's first continuous stainless steel pickling line.

Because this is a large stainless line requiring special care to prevent surface marring or scratching, consideration had to be given to the drive system. The drive requirements were for precisely controlled tension over wide speed ranges with extremely reliable control. Reliance V★S Drives with built-in electronic regulators keep the line moving and afford the flexibility to permit line speeds from 5 to 50 feet per minute for strip .007 to .187 inches thick and 10 to 20 inches wide.

Four compact V★S Control Units which house the factory-wired motor-generator sets and the control panels supply power to the motors for each half of the twin line. The "packaged" feature of the drive means extreme ease of installation and a great saving in installation cost plus the ability to tailor the drive system to the actual requirements. This "tailoring" meant that wide constant-horsepower speed range motors could be used to fit in with the line speed variables. These variables were created by the need for running strip of varying thicknesses and widths through the line at speeds dictated by the annealing furnace "constant tons per hour" limits.

This is a good example of the ability of Reliance to tailor drive systems to the specific application requirements of the steel industry. Write for Bulletin A-1555. D-1805-A

RELIANCE ELECTRIC AND ENGINEERING CO.

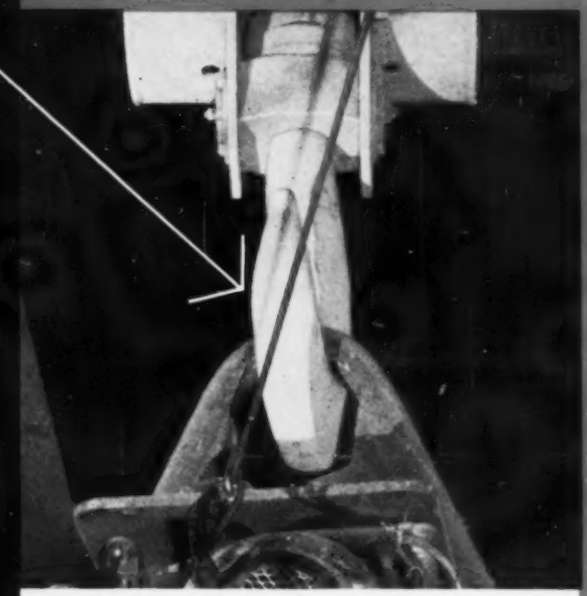
DEPT. 117A, CLEVELAND 10, OHIO – CANADIAN DIVISION: WELLAND, ONTARIO

Sales Offices and Distributors in Principal Cities

"Electric and Open Hearth Steel Castings from 1 lb. to 100 tons"

Photo Taken at
WEST VIRGINIA STEEL CORP.
Huntington, West Virginia

portable ingot stripper



lower cost... greater efficiency

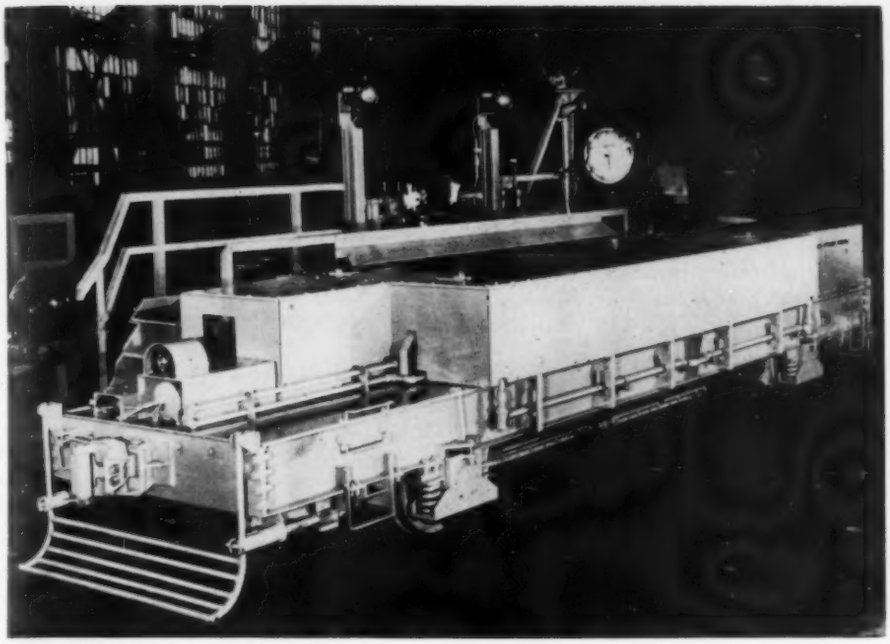
Present users of our Portable Ingot Stripper report savings in mold cost and reduced overhead expense as the crane can be used for other jobs when the stripper is not in use. Two sizes available—250 and 450 tons—easily modified to handle hot tops.

Write for New Portable Ingot Stripper Folder

Pittsburgh
ENGINEERING & MACHINE CO.

Division of Pittsburgh Steel Foundry Corporation

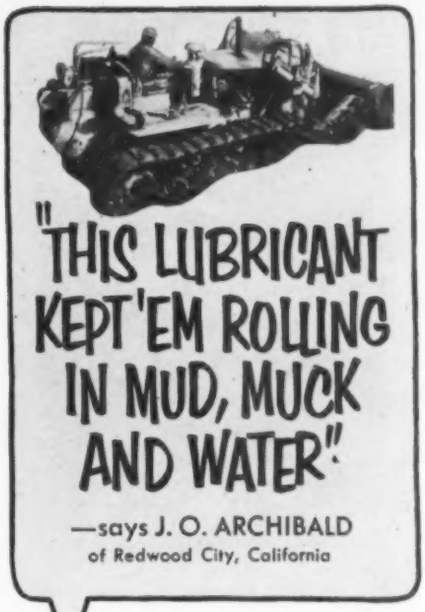
P. O. BOX 906, PITTSBURGH 30, PENNSYLVANIA
PLANT AT GLASSPORT, PENNSYLVANIA



SCALE CAR

▲ Pennsylvania Engineering Corp., has announced a new blast furnace scale car that contains two 160 cu ft bins which are air operated, drawing from the same air supply as the air brakes.

Self-propelled by two d-c motors, the car can travel at speeds up to 500 fpm with full load. Weighing equipment consists of an automatic recording Howe scale which, at the press of a button by the operator, weighs the bin loads and automatically records on tape.



"THIS LUBRICANT KEPT 'EM ROLLING IN MUD, MUCK AND WATER"

—says J. O. ARCHIBALD
of Redwood City, California

The job was clearing 500 acres of salt marsh for crystallizing ponds. To quote, "We selected LUBRIPLATE No. 107 for track and general lubrication and LUBRIPLATE APG-140 for transmissions and final drives. During the entire job there was no replacements of track rollers nor any tie-ups of equipment due to parts replacement or breakage!"

REGARDLESS OF THE SIZE AND TYPE OF YOUR MACHINERY, LUBRIPLATE LUBRICANTS WILL IMPROVE ITS OPERATION AND REDUCE MAINTENANCE

LUBRIPLATE LUBRICATION

MAKES CARS AND TRUCKS RUN BETTER AND LAST LONGER

LUBRIPLATE H.D.S. MOTOR OIL . . . THE OIL THAT NEEDS NO ADDITIVES

For nearest LUBRIPLATE distributor see Classified Telephone Directory. Send for free "LUBRIPLATE DATA BOOK" . . . a valuable treatise on lubrication. Write LUBRIPLATE DIVISION, Fiske Brothers Refining Co., Newark 5, N. J. or Toledo 5, Ohio.

Red Circle Rolls for all Purposes

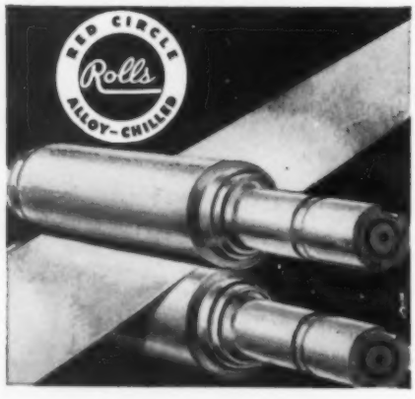
The Red Circle on the Roll is the Hyde Park mark of Quality. Hyde Park makes rolls for every type mill.

Chilled Rolls
Alloy Iron Rolls
Moly Rolls
Nickel Chilled Rolls
Grain Rolls
Cold Rolls
Sand Rolls

for
Finer Finish, Longer Life
and Greater Tonnage
specify Red Circle

Hyde Park

FOUNDRY & MACHINE CO.
Hyde Park, Westmoreland County, Pa.
ROLLS • ROLLING MILL MACHINERY
GREY IRON CASTINGS



This unusually rugged scale unit has a rated capacity of more than 50 per cent above operating requirements and has knife edges in the scale which are removable and reversible for easy maintenance. Since the unit operates under ore, coke and limestone stock bins, it is equipped with both headlights and powerful floodlights which illuminate the bins. The entire car is very heavily constructed and properly guarded against falling materials.

A unique series of safety devices have been included in the design of the car, such as a safety linkage that prevents operation of the car while the hoppers are open. A "cow catcher" at each end of the car operates against a spring loaded pin so that when the car strikes any obstruction, the pin moves back against a limit switch which automatically cuts the power and sets the brakes. The car is also equipped with a deadman control so that if the operator leaves the station, the car will stop automatically. An electric gong is hooked into the control system so that any time power is applied to any motor, the gong will sound continuously.

COMPUTER

▲ Available from Hagan Corp., is a pneumatic pressure-ratio computer that measures compressor inlet and outlet pressures and simultaneously

calculates the ratio of these two pressures.

Wide range, flexibility, accuracy and pneumatic signal transmission are some of the outstanding features of this unit.

CM

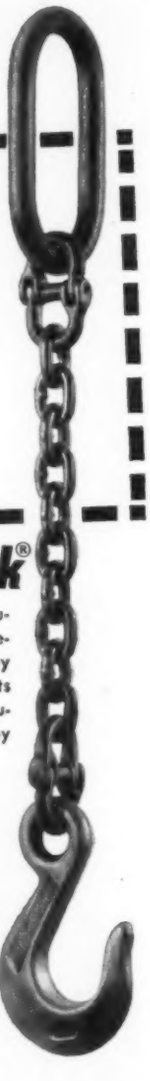
HERC-ALLOY®

the original alloy steel chain

FOR THE FIRST TIME
Assemblies are now available with a choice of coupling links:

WELDED coupling links
...the type with which you are thoroughly familiar.

DETACHABLE coupling links
...the new type called Hammerlok introduced by Columbus McKinnon in 1955.



CM Hammerlok®

The "do-it-yourself" reusable coupling link that permits you to make-up or rebuild your own Herc-Alloy assemblies with all components furnished by your local distributor. Simple and safe. Endorsed by leading alloy chain users.

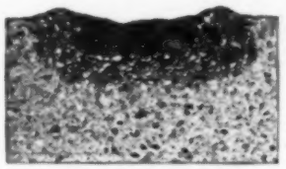
CALL YOUR CM DISTRIBUTOR or write for helpful literature on alloy chain assembly, care, use and inspection.

CM
HOISTS AND CHAIN

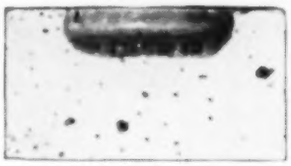
COLUMBUS McKINNON
CHAIN CORPORATION
TONAWANDA, NEW YORK
Regional Offices: New York • Chicago • Cleveland
In Canada: McKinnon Columbus Chain Limited, St. Catharines, Ontario

ACTION of MOLTEN ALKALI

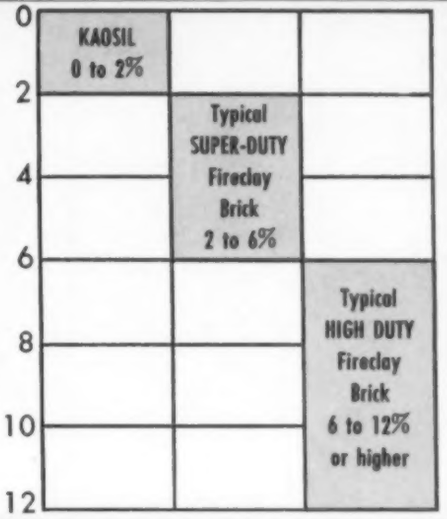
on high duty Fireclay Brick



and on KAOSIL



LINEAR SUBSIDENCE in the standard load test for SUPER-DUTY Fireclay Brick Load 25 lb./sq. in. Temperature 2640°F.



These illustrations show why Harbison-Walker KAOSIL excels for many furnace requirements in iron and steel plants

THE remarkable resistance of KAOSIL to corrosion in atmospheres containing volatile alkalies, contributes greatly to its successful use in Blast Furnace Stoves. The photographs above show the results of five hour cup tests with sodium carbonate at 2550°F. While some erosion occurred with both brick, there was a great difference in the degree of penetration. The aluminous High Duty fireclay brick was deeply penetrated and corroded, while KAOSIL was not penetrated beyond the zone of erosion and the cup still held the glass.

Among applications for which KAOSIL is especially suited are: *Blast Furnace Stoves*—combustion wells, domes, checkers; *Soaking Pits*—sidewalls, regenerator arches, top courses of checker chamber walls, and covers; *Open Hearths*—fantail roof, regenerator roof, side walls above checkers, checker arches; *Heating Furnaces*—suspended or sprung arch roofs, walls; *Hot Metal Mixers*—above metal line; *Miscellaneous*—piers under load in soaking heats—in heavily insulated arches and walls—arches of unusually wide span.

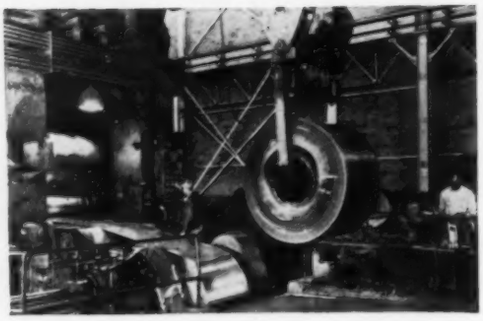
a SEMI-SILICA fireclay refractory of *superior* quality

1. Kaosil is made with hard-fired siliceous kaolin of exceptional purity. (Silica 75 to 76%—extremely low alkali content—less than ½%).
2. Kaosil is formed by the power-press method which provides uniform texture, free from laminations—and assures superior workmanship.
3. Kaosil remains rigid and does not become pyroplastic nor shrink in soaking heats up to its temperature limit.
4. The temperature of incipient vitrification of Kaosil is higher than that of the best aluminous high duty fireclay brick. This property contributes to its excellent spalling resistance.
5. In atmospheres containing volatile alkalies at high temperatures, Kaosil becomes glazed and penetration is thereby greatly retarded.

HARBISON-WALKER REFRACTORIES COMPANY
AND SUBSIDIARIES
World's Most Complete Refractories Service
GENERAL OFFICES: PITTSBURGH 22, PENNSYLVANIA

MANSAVER® GRABS FEED TEMPER MILLS

Handling Coils of Various Widths



Mansaver Grab Style G-1418 operates entirely under the remote control of the man at the right, with no floor assistance.

Its motor-driven arms adjust to coils of various widths, and takes them safely from storage to mill stands. Supplied with twin suspension (as shown), single suspension, or motor-driven turntable. Mansaver Grabs are supplied for handling sheet, wire, rods and bars, as well. Write for catalog and name of our nearest representative.

Mansaver Grabs Are Built To PREVENT ACCIDENTS and PRODUCTION DELAYS—Not For Low FIRST COST.

MANSAVER INDUSTRIES, INC., 3116 East St., New Haven, Conn.

. . . complete lamp protection with *Adalet* vapor-tight lighting

Inside or outside, wherever the lighting need, get better protection, greater safety with Adalet vapor-tight and weather-proof lighting.

From junction box to reflector, globe and shock-proof guard (that can't shake off), Adalet has a complete line . . . quality built for rugged service, engineer-designed for better lighting. 100, 200 and 500-watt sizes. Get the whole story — send for Catalog Section E.

LIGHTING FLEXIBILITY

SHALLOW DEEP 30° ANGLE

WIRING FLEXIBILITY

MOUNTING FLEXIBILITY

THE *Adalet* MANUFACTURING COMPANY
14300 LORAIN AVENUE • CLEVELAND 11, OHIO

Pressure-ratio is a key variable which must be regulated in order to prevent flow instability or surge in exhauster, compressor or blower control systems. The instrument indicates pressure-ratio on an integral scale and generates a pneumatic signal proportional to pressure-ratio for use in a control system. The computer is available for application in ranges of static pressures of from 0 to 10 psia up to 0 to 400 psig. Higher static pressure ranges are available. Available for computing on a gage or absolute pressure basis, the computer can also be supplied with either a zero base or suppressed scale indication.

Ratio calculating accuracy of the computer is high even when the input static pressure turndown ranges are as great as 30 to 1. The computer's pneumatic output signal can be used for control within the normal distance of pneumatic transmission, since the pneumatic output is proportional to the ratio. Remote recording or indication of the ratio can supplement the local mechanical indication within the computer.

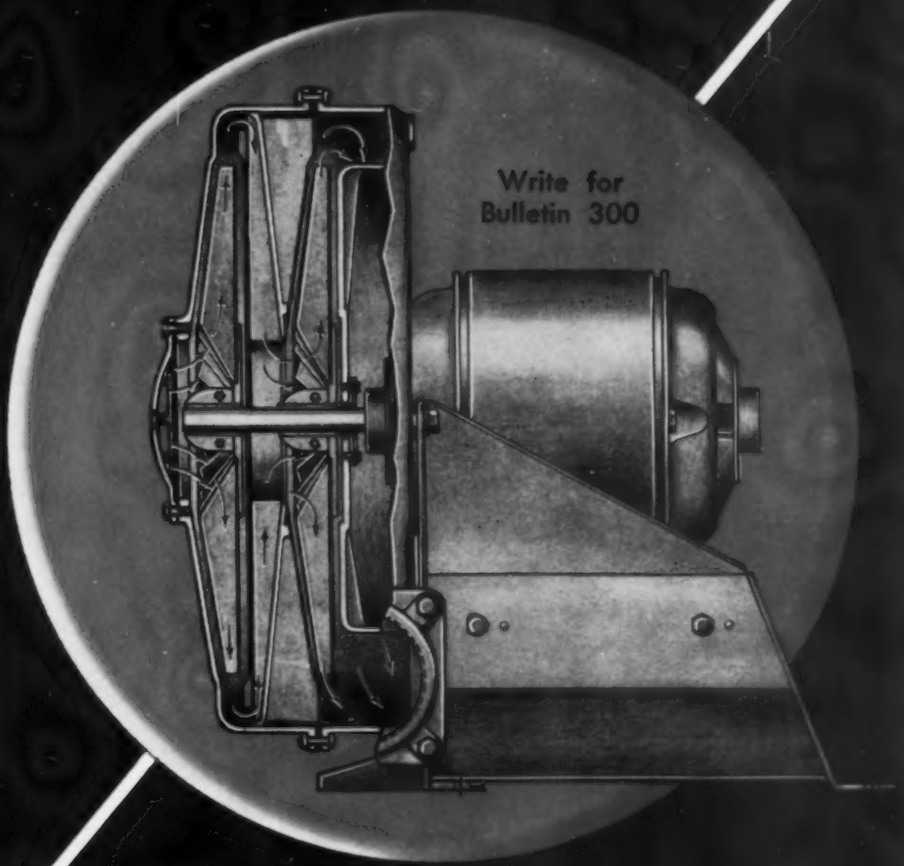
Book Reviews . . .

A **"Scrap Yard Handbook"** used by the Army, Navy, Air Force, and Marine Corps has just been made available to industry through the Office of Technical Services, U. S. Department of Commerce.

The book was prepared by the Armed Forces to point out the most practical methods in the recovery and disposal of ferrous and nonferrous scrap and waste materials at military activities, and to provide information as to the methods of accomplishing this task. It aims expressly at overcoming any possible lack of coordination of disposal techniques or lack of knowledge of commodities in the scrap and waste material area.

The volume contains sections on introductory information, "Organization of Scrap Yards," "Degrees of Identification and Segregation of Scrap Per Type of Yard," "Customary Preparations Procedures of Scrap Per Type of Military Scrap Yard," "Various Grades of Scrap and Waste Materials," "Special Problems and Techniques," and "Alphabetical Listing of Additional Waste Material Hints."

North American TURBO BLOWERS are Trouble-Free



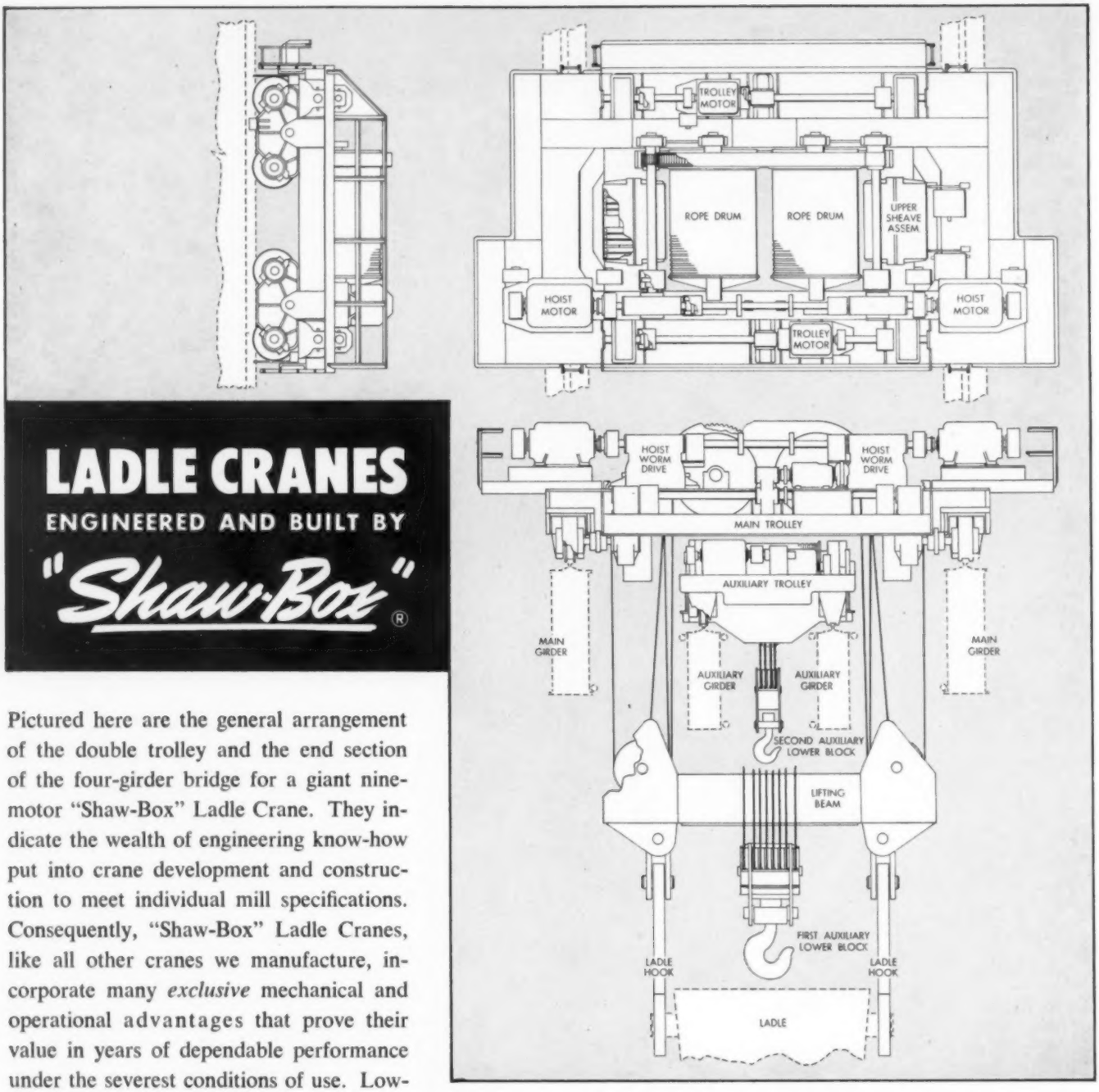
Lower Bearing Loads—

Light Weight Impellers • Balanced and Thoroughly Tested

60 to 7560 cfm • 4 to 32 osi • ⅓ to 60 hp
1800 or 3600 rpm Impeller Speeds
Direct, V-Belt, or Coupled Drives
1, 2, or 3 Stages • 91 Standard Models

NORTH AMERICAN COMBUSTION

The NORTH AMERICAN
Manufacturing Company
4455 East 71st St. · Cleveland 5, Ohio



LADLE CRANES

ENGINEERED AND BUILT BY

"Shaw-Box"®

Pictured here are the general arrangement of the double trolley and the end section of the four-girder bridge for a giant nine-motor "Shaw-Box" Ladle Crane. They indicate the wealth of engineering know-how put into crane development and construction to meet individual mill specifications. Consequently, "Shaw-Box" Ladle Cranes, like all other cranes we manufacture, incorporate many *exclusive* mechanical and operational advantages that prove their value in years of dependable performance under the severest conditions of use. Low-cost operation, complete safety, and simplified maintenance likewise help make every "Shaw-Box" Steel Mill Crane a continuously productive investment in load-handling efficiency.

Whether your plans call for a ladle crane of 100 to 400-ton capacity, a soaking pit carriage, or a crane to handle slabs or plate, we invite your inquiry. Our staff of engineers will gladly apply their varied experience in interpreting AISE specifications or your own. In this way, you can make sure you get individualized equipment that will be the most economical to buy and use.

MAXWELL M&M MANNING & MOORE INC. TRADE MARK

"Shaw-Box"® CRANES

MANNING, MAXWELL & MOORE, INC.

Muskegon, Michigan

BUILDERS OF "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES. MAKERS OF 'ASHCROFT' GAUGES, 'HANCOCK' VALVES, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN' AND 'AMERICAN-MICROSEN' INDUSTRIAL INSTRUMENTS, AND AIRCRAFT PRODUCTS.

PB 121093 *Scrap Yard Handbook* may be ordered from OTS, U. S. Department of Commerce, Washington 25, price $2.50. It is dated Oct. 1955 and contains 127 pages.

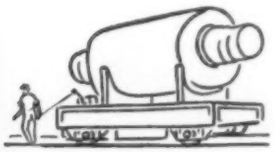
"Elevated Temperature Properties of Carbon Steels" has been recently published by the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa. It is designated as ASTM Special Technical Publication No. 180, contains 68 pages, 8½ x 11, is heavy paper bound, and sells for $3.75. The data is compiled by and issued under the auspices of the data and publication panel of the ASTM-ASME Joint Committee on the Effect of Temperatures on the Properties of Metals, it is the fourth publication in a current series by this committee, and contains data for tensile and yield strength, elongation and reduction of area, stresses for creep rates of 0.0001 and 0.00001 per cent per hour and rupture strengths for 100, 1,000, 10,000, and 100,000 hours covering killed carbon steel (0.18 to 0.24C), ASTM A 201 Grade B plate steel (0.24 C max), ASTM A 106 Grade B pipe steel (0.30 C max), killed carbon steel (0.27 to 0.58 C), aluminum killed steel, open steel (rimmed or capped), and miscellaneous carbon steels (limited data available). Properties given are in graphical form and supplemented by copies of original data sheets.

"Abstracts of the Literature on Semiconducting and Luminescent Materials and Their Applications, 1954 Issue" has recently been published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. The book contains 200 pages, 8½ x 11 in., is heavy paper bound, and sells for $5.00. The data is compiled by the Solid State Devices Division and the Physical Chemistry Division of the Battelle Memorial Institute, sponsored by The Electrochemical Society, Inc., and is comprised of over 750 abstracted articles. These abstracts contain the most important experimental results or conclusions and, minimize the necessity for reference to the original articles. The inclusion of this information, together with supplying the subject and author indices, allows the compilation to serve as a complete desk reference in this area of technology. Subjects covered are germanium; silicon; carbon, boron and other semiconductors; selenium and tellurium; selenides and tellurides; intermetallics; oxides; sulphides, halides; organics; fluorescense and phosphorescence; and there are approximately twelve pages of abstracts on theory.

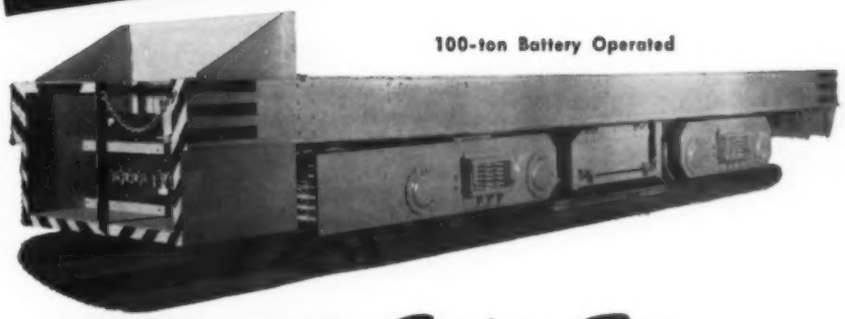
"Geology and Ourselves" by F. H. Edmunds has recently been published by the Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. The book contains 256 pages, 9 x 6 in., is cloth bound, and sells for $10.00. The author has for more than 30 years been a member of the staff of the Geological Survey of Great Britain. The book presents an outline of the broad principles of geology, and an explanation of how the subterranean contents and structure of land can be deduced by geological means. The comparatively new studies of geophysics, geochemistry and soil-mechanics are also introduced.

(*Please turn to page 252*)

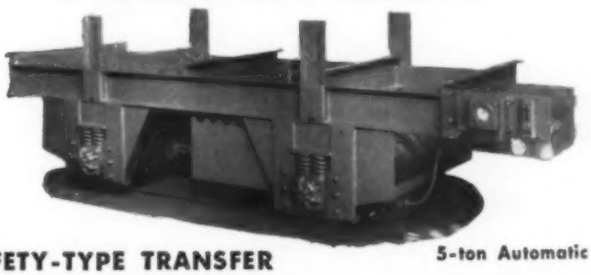
HANDLES THE BIG LOADS WITH BIG SAVINGS



100-ton Battery Operated



ATLAS *Safety Type* TRANSFERS



5-ton Automatic Controlled

ATLAS SAFETY-TYPE TRANSFER CARS can be provided in almost any capacity for storage battery, diesel or gas-electric, or cable reel service.

They are safe because there is only one control lever, and the car moves only when the operator holds the lever.

Request "Walk-Along" Bulletin 1283.

ATLAS CAR & MFG. CO.
1100 IVANHOE ROAD
CLEVELAND 10, OHIO

ENGINEERS AND MANUFACTURERS SINCE 1896

Applications for AISE Membership

Active

RENE J. ARMBRUSTER
Draftsman Electrical
United States Steel Corp.
Fairless Works
Fairless Hills, Pa.

GERALD GUY BARKER
Production Assistant
Kaiser Steel Corp.
Fontana, Calif.

EDGAR M. BERGER
Reclamation Supervisor
Bethlehem Steel Co.
Bethlehem, Pa.

FRANK J. BURGERT
Superintendent of North Plan
Granite City Steel Co.
Granite City, Ill.

THEODORE CHORAZAK
Electrical Foreman
Bethlehem Steel Co.
Lackawanna, Pa.

WILLIAM E. COLLINS
Mechanical Foreman
Republic Steel Corp.
Warren, Ohio

CHESTER Q. CROWE
Machine Shop Foreman
Republic Steel Corp.
Warren, Ohio

WARREN J. CULLEN
Superintendent of Orders
Bethlehem Pacific Coast Steel Corp.
Vernon, Calif.

J. H. EDWARDS
Electrical Foreman
Republic Steel Corp.
Gadsden, Ala.

W. R. FANKHAUSER
Blast Fce. Operating Practice Engineer
United States Steel Corp.
Youngstown, Ohio

CHARLES T. FIETZ
Engineer Plant Eng. Dept. Steel Mill
Bethlehem Pacific Coast Steel Corp.
Vernon, Calif.

LEO J. FITZPATRICK, JR.
Ass't. to Gen. Foreman Hot Strip Fin. Mill
Jones & Laughlin Steel Corp.
Pittsburgh, Pa.

JOHN J. FREEH
Experimental Engineer
Bethlehem Steel Co.
Bethlehem, Pa.

SAMUEL GILLEY
Chief Draughtsman
Richard Thomas & Baldwins Ltd.
Glamorgan, South Wales, Great Britain

KENNETH L. GRANT
Sup't. Electric Furnaces
Bethlehem Pacific Coast Steel Corp.
Vernon, Calif.

GLENN HAMMOND
Shift Foreman 46-Inch Blooming Mill
Kaiser Steel Corp.
Fontana, Calif.

SMITH HASTINGS
Millwright Foreman Blooming Mills
Republic Steel Corp.
Warren, Ohio

PAUL V. HYLAND
Contracting Manager
Kaiser Steel Corp.
Los Angeles, Calif.

JOHN E. JOHNSON
Field Engineer
Republic Steel Corp.
Buffalo, New York

RICHARD L. KLAVER
Looper
Bethlehem Steel Co.
Lackawanna, New York

WILHELM KOHLER
Dipl.-Ing.
Neunkircher Eisenwerk
Aktiengesellschaft vorm.
Gebr. Stumm
Neunkirchen/Saar, Germany

STEPHEN J. KOS
Ass't. Foreman Carpenter Dept.
Bethlehem Steel Co.
Lackawanna, New York

JOHN L. OMINSKI
Foreman
Alan Wood Steel Co.
Conshohocken, Pa.

WILLIAM F. SHARP
Trainee Tech. Operating Training Program
Republic Steel Corp.
Buffalo, New York

WILLIAM H. MALONE
Engineer
Republic Steel Corp.
Alabama City, Ala.

HORACE B. MENEFEE
Engineer
Republic Steel Corp.
Gadsden, Ala.

CARL JOSEPH MURRAY
Works Manager
Colorado Fuel & Iron Corp.
Wickwire Spencer Div.
Buffalo, New York

DEWEY O. OLSON
Vice President in Charge of Operations
Follansbee Steel Corp.
Follansbee, W. Va.

EDGAR E. PICKARD
Sup't. Shops
Homestead Works
United States Steel Corp.
Munhall, Pa.

CARLOS A. PRADO
Ass't. Chief of Production
Acerias Paz del Rio
Bogota, Colombia, South America

CHARLES E. REED, SR.
Ass't. Sup't. Construction Div.
Bethlehem Steel Co.
Bethlehem, Pa.

CHARLES M. SCHULTZ
Executive Vice Pres.
Jersey Shore Steel Co.
Jersey Shore, Pa.

C. ROBERT SCOTT
Foreman Blooming Mill
Alan Wood Steel Co.
Conshohocken, Pa.

WALTER F. SLANEY
Foreman
Inland Steel Co.
Indiana Harbor, Ind.

CYRUS N. SMITH, JR.
Millwright Foreman
Republic Steel Corp.
Warren, Ohio

EDWARD A. STAUB
Design Draftsman
Youngstown Sheet & Tube Co.
Youngstown, Ohio

DANIEL C. STEIN
Maint. Supervisor of Rolling Mills
Alan Wood Steel Co.
Conshohocken, Pa.

WILLIAM H. SYKES
General Foreman Electrical Maint.
Columbia-Geneva Steel Div.
Torrance, Calif.

RICHARD TEGTMEIER
Trainee
United States Steel Corp.
Fairless Hills, Pa.

JAMES F. TURNER
Electrical Engineer Const.
Tennessee Coal & Iron Div.
United States Steel Corp.
Birmingham, Ala.

CHARLES N. VAN HOUTEN
Sup't. Maint. Coal Mines
Tennessee Coal & Iron Div.
United States Steel Corp.
Fairfield, Ala.

JOHN GORDON VENATOR
Mechanical Foreman Hot Mills
Dominion Foundries & Steel Co.
Hamilton, Ontario, Canada

WILLIAM WACHOB
Gen. Foreman Furnace Repair
Columbia-Geneva Steel Div.
United States Steel Corp.
Pittsburg, Calif.

FLOYD E. WILLIAMS
General Foreman
Republic Steel Corp.
Warren, Ohio

C. H. WINDLE
Sup't. Cold Strip Dept.
Republic Steel Corp.
Warren, Ohio

JAMES N. WOGNUM
Chief Research Engineer
Acme Steel Co.
Chicago, Ill.

LUDWIK ZDANOWICZ
Chief Engineer
Calstrip Steel Corp.
Los Angeles, Calif.

Associate

T. M. BIRCH
Sales Engineer
Cutler-Hammer, Inc.
Milwaukee, Wis.

WILLIAM A. BOYD
President
Vail Rubber Products Corp.
Hammond, Ind.

CESAR MUZQUIZ-CARRANZA
Sales Engineer
M. Castellvi, Inc.
New York, N. Y.

PAUL H. CLARKE
Sales Engineer
Osborn Mfg. Co.
Cleveland, Ohio

WILLIAM H. CODDINGTON
Sales Engineer
Bigelow Liptak Corp.
Detroit, Mich.

ERIC F. ENBLOM
Service Manager
Yale & Towne Mfg. Co.
Chicago, Ill.

EUGENE B. GANLEY
Sales Representative
American Shear Knife Co.
Homestead, Pa.

ROBERT K. HEALEY
Sales Representative
Simplex Wire & Cable Co.
Cleveland, Ohio

CLAYTON A. HELLER
Sales Engineer
The Babcock & Wilcox Co.
New York, N. Y.

ROWAN M. HOWE
Sales Representative
Phelps Dodge Copper Product
Cleveland, Ohio

JOHN JAMES HUDSON
Hamilton District Manager
Reliance Electric & Eng. Ltd.
Hamilton, Ontario, Canada

DONALD J. LOESER
Representative
Tool Steel Gear & Pinion Co.
Cincinnati, Ohio

KARL SANDERSON
District Sales Manager
Sunbeam Corp. Industrial Furnace Div.
Chicago, Ill.

M. B. SAVAGE
Sales Engineer
M. B. Savage Co.
Detroit, Mich.

ALOYSIUS LEONARD SPALDING
Regional Manager
L. R. Kerns Co.
Chicago, Ill.

ALVIN A. LUCE
District Engineer
The Torrington Co.
Rochester, New York

CHRIS McCRIRIE
President
Reliable Bearing & Supply Co.
San Bernardino, Calif.

D. J. McGOWAN
District Manager
The Ramtite Co.
Chicago, Ill.

PATRICK D. McGUIRE
Maintenance Specialist
General Electric Co.
Chicago, Ill.

R. N. McMICHAEL
Squad Supervisor
Koppers Co., Inc.
Pittsburgh, Pa.

JOHN J. McNEILL
Secretary-Treasurer
Vail Rubber Products Corp.
Hammond, Ind.

ALFRED MOURON
Project Manager
The Rust Engineering Co.
Birmingham, Ala.

ROBERT H. OWEN
Sales Engineer
Electric Controller & Mfg. Co.
Cleveland, Ohio

EDWARD H. PARROTT
Industrial Representative
General Petroleum Corp.
Los Angeles, Calif.

ALAN C. PETERSON, SR.
Project Engineer
Hot Mill Consulting Service
Cleveland Heights, Ohio

JULIAN A. PORTER
President
Down River Casting Co.
Rockwood, Mich.

CLYDE W. PROSSER
Shop Sup't.
Iron City Spring Co.
Pittsburgh, Pa.

R. G. SCHOLL
Manager Industrial Equip. Dept.
Westinghouse Electric International Co.
New York, N Y

ALEXANDER SHASHATY
Design Engineer
Enterprise Co.
Columbiana, Ohio

CARL W. SINCLAIR
President and Treasurer
Sales Engineering Co., Inc.
Salt Lake City, Utah

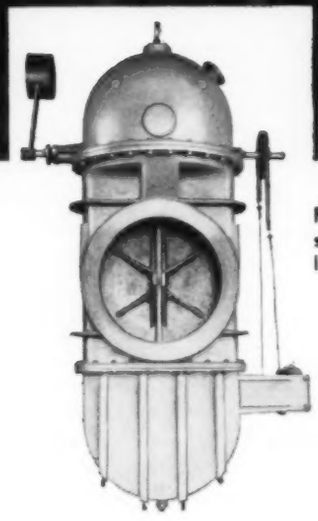
CLINTON G. SMITH
Philadelphia District Manager
Electric Machinery Mfg. Co.
Minneapolis, Minn.

FRANK A. TULLY, JR.
Service Engineer
General Electric Co.
Buffalo, New York

DAVID R. WARD
Field Engineer
Electric Controller Div.
Square D Co.
Ardmore, Pa.

JOHN P. WELLS
Sales Engineer
General Electric Co.
Detroit, Mich.

Freyn-Jansen Stove Valve



Freyn-Jansen Stove Valve reduces stove changing time, prevents gas leakage at the burner.

For over 25 years this stove valve has satisfied blast furnace operators in many countries. Here's why:

. . . reduces stove changing time

It replaces the conventional stove door providing quick, effortless action that saves time and work in opening and closing the burner inlet to the stove, regardless of burner opening size. A counterweighted valve operating shaft permits fast, easy operation either by manual lever, motor actuator or compressed air.

. . . prevents gas leakage

Permanently installed with bolted flanges between the burner discharge and the stove inlet, the Freyn-Jansen Valve prevents any gas leakage.

. . . provides tight, sure closure

It's designed so that cold blast pressure forces the valve against the seat, not away from it. In fact, the higher the pressure, the tighter the valve seats—makes it impossible for the disc to be blown off the stove.

. . . eliminates maintenance

The conventional stove door requires maintenance of its refractory lining and gasket between the door and stove. Neither refractory lining nor gasket at the valve seat is used on the Freyn-Jansen Valve.

Send for descriptive information that gives you all the facts, or consult our engineers.

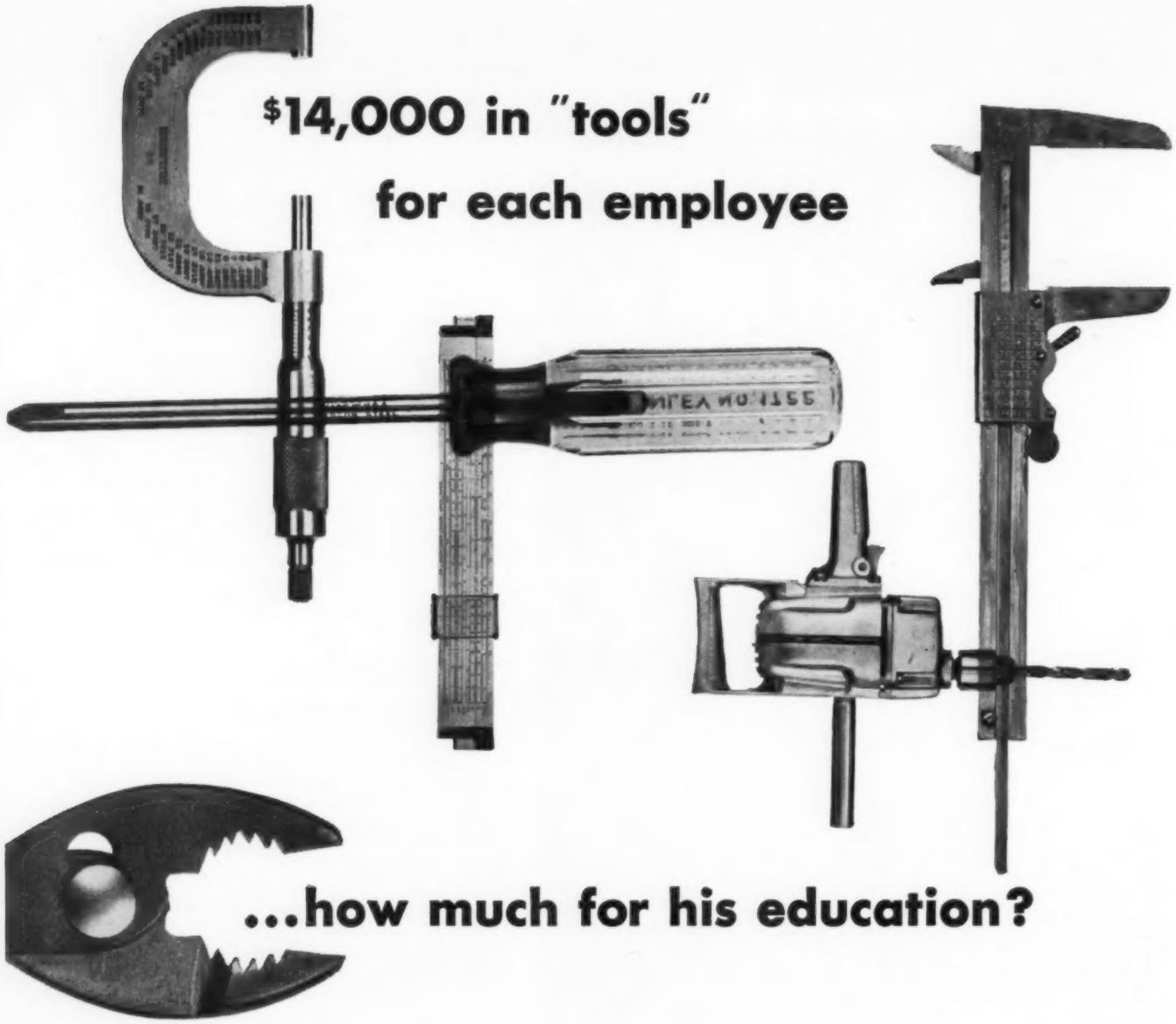
KOPPERS

KOPPERS COMPANY, INC.

Freyn Department

Engineering & Construction Division

KOPPERS BUILDING • PITTSBURGH 19 *Associated with* Ashmore, Benson Pease & Co. Ltd., Stockton-on-Tees, ENGLAND; De Laître & Freyard, Paris, FRANCE



$14,000 in "tools" for each employee

...how much for his education?

Today, business invests an average of $14,000 in each employee's job. The question for businessmen is: Are we training enough people who can hold down these jobs? Schools are the answer. And it's simple self interest to help community groups get the teachers and equipment schools need. Shortage right now: 200,000 classrooms, 165,000 teachers!

PUBLIC SERVICE ADVERTISING COUNCIL

Want to find out how to help in *your* community?
Get specific information by writing:
Better Schools, 9 East 40th Street, New York, N. Y.

Here's a drum that can't be beat!

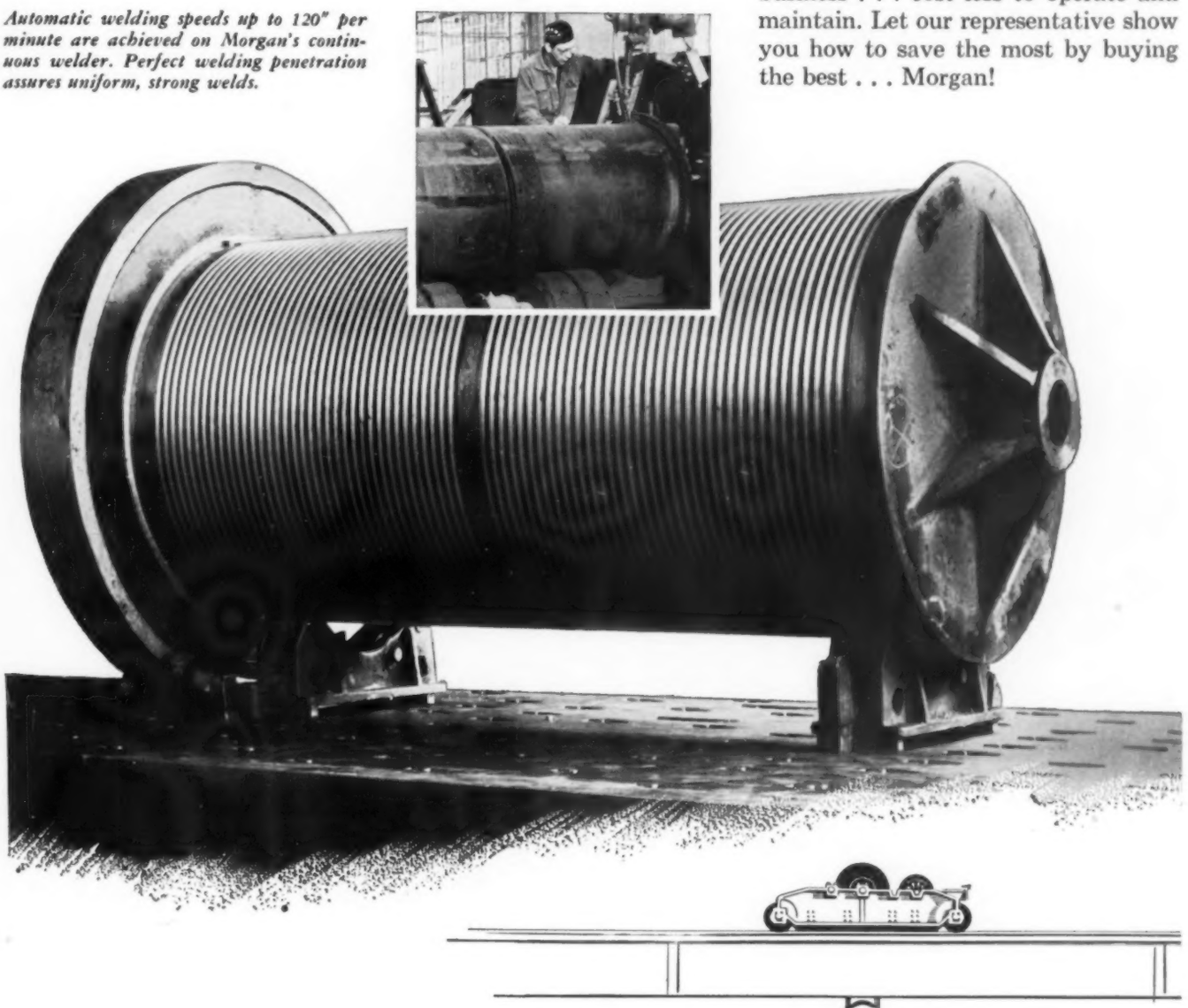
• *Fabricated drums* in Morgan cranes are structurally stronger than cast drums . . . yet they weigh less.

Automatic welding of Morgan drums with the world's largest continuous welding machine assures uniform, sound joints and seams.

Crane girders, too, are welded automatically, making them stronger and lighter. Morgan welders are qualified in accordance with A.S.M.E. and A.W.S. codes.

Performance records prove conclusively that Morgan cranes are the best in the business . . . cost less to operate and maintain. Let our representative show you how to save the most by buying the best . . . Morgan!

Automatic welding speeds up to 120" per minute are achieved on Morgan's continuous welder. Perfect welding penetration assures uniform, strong welds.

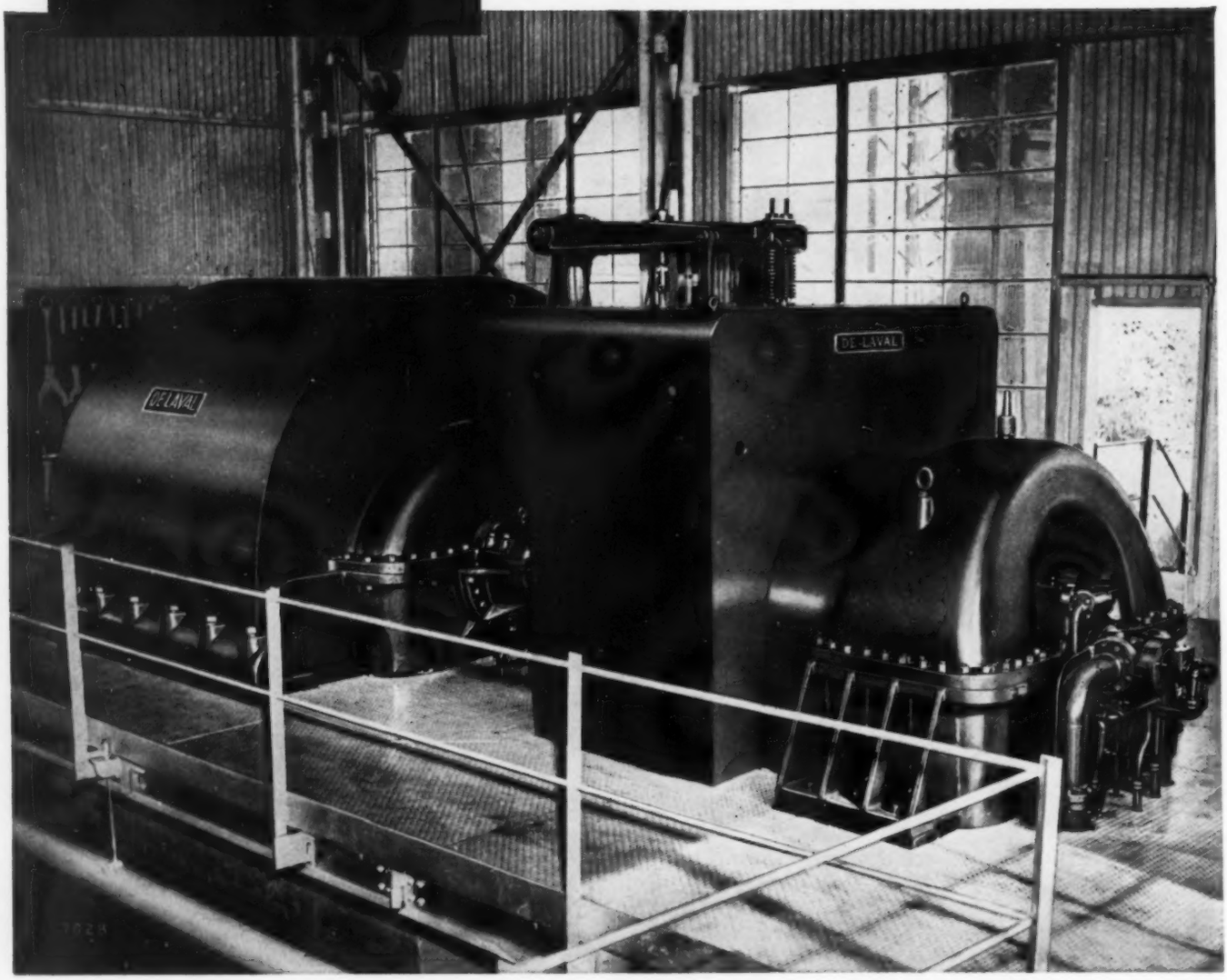


The Morgan Engineering Company, founded in 1868, manufactures overhead electric traveling cranes, gantry cranes, open hearth special cranes, plate mills, blooming mills, structural mills, shears, saws, and auxiliary equipment.

THE
MORGAN
ENGINEERING CO. *Alliance, Ohio*

DE LAVAL CENTRIFUGAL BLOWER

delivers 75,000 cfm for southern steel mill



This De Laval 75,000 cfm blast furnace blower in a southern steel mill is driven by a 9,450 hp De Laval turbine operating at 2,900 rpm. Discharge pressure of the blower is 35 psig.

De Laval blowers have what it takes to give long service. The rugged casings and sturdy, perfectly balanced rotors are built to take punishment. The pressure lubricated sleeve bearings and Kingsbury type thrust bearing add durability and reduce maintenance. Both the turbine and blower are De Laval-designed and De Laval-made for top performance.

De Laval centrifugal blowers and compressors are built in single and multi-stage types to supply air in volumes up to 150,000 cfm for all classes of service in steel, gas and coke plants. The wealth of application experience acquired by De Laval over the years assures a correct and economical solution to your blower problem. Consult your De Laval Sales Engineer.

DE LAVAL *Centrifugal Blowers*

DE LAVAL STEAM TURBINE COMPANY

870 Nottingham Way, Trenton 2, New Jersey

DL 362

LOW VOLTAGE SWITCHGEAR through 600 v a-c, 250 v d-c, 15,000 through 150,000 amp interrupting, 6000 amp continuous.

UNIT SUBSTATIONS—primary and secondary, indoor and outdoor construction—in all standard ratings, dry, askarel or oil transformers.

ISOLATED PHASE BUS through 138 kv and 10,000 amp.

METAL-CLAD SWITCHGEAR in ratings from 2400 v through 15 kv, 50 through 500 mva interrupting and 2000 amp continuous.

INDIVIDUAL BREAKERS, a-c and d-c, 15,000 through 150,000 amp interrupting, 6000 amp continuous.

NONSEGREGATED PHASE BUS through 15 kv and 6000 amp.

Economical: an I-T-E Power Package

An I-T-E Power Package includes the complete power handling facilities for a new construction project, building addition, or expansion of electrical service—one unit or a complete system for every application from generation to end use. You save in sound planning, easier installation, coordinated delivery, and assured performance—a better investment in every way.

For more information, contact the I-T-E sales office nearest you or write I-T-E Circuit Breaker Company, 19th & Hamilton Sts., Philadelphia 30, Pa.

I-T-E CIRCUIT BREAKER COMPANY
Switchgear Division

I-T-E

CONGRATULATIONS on Your 15th Anniversary

May 1st marked the Fifteenth Anniversary of the introduction of the Series E Savings Bonds. In a deeper sense it was *your* anniversary, because you, in 1941, helped to initiate and build a thrift movement new to America—The Payroll Savings Plan for the purchase of Series E Bonds.

In the intervening years millions of men and women have invested billions of dollars in Series E Bonds through the Payroll Savings Plan.

Today, forty million Americans hold Series E and Series H Bonds (the H Bond was introduced in 1952) with a cash value of more than $40 billion—a reservoir of future purchasing power. In addition, Savings Bonds have paid for college educations, new homes, retirements and other family needs.

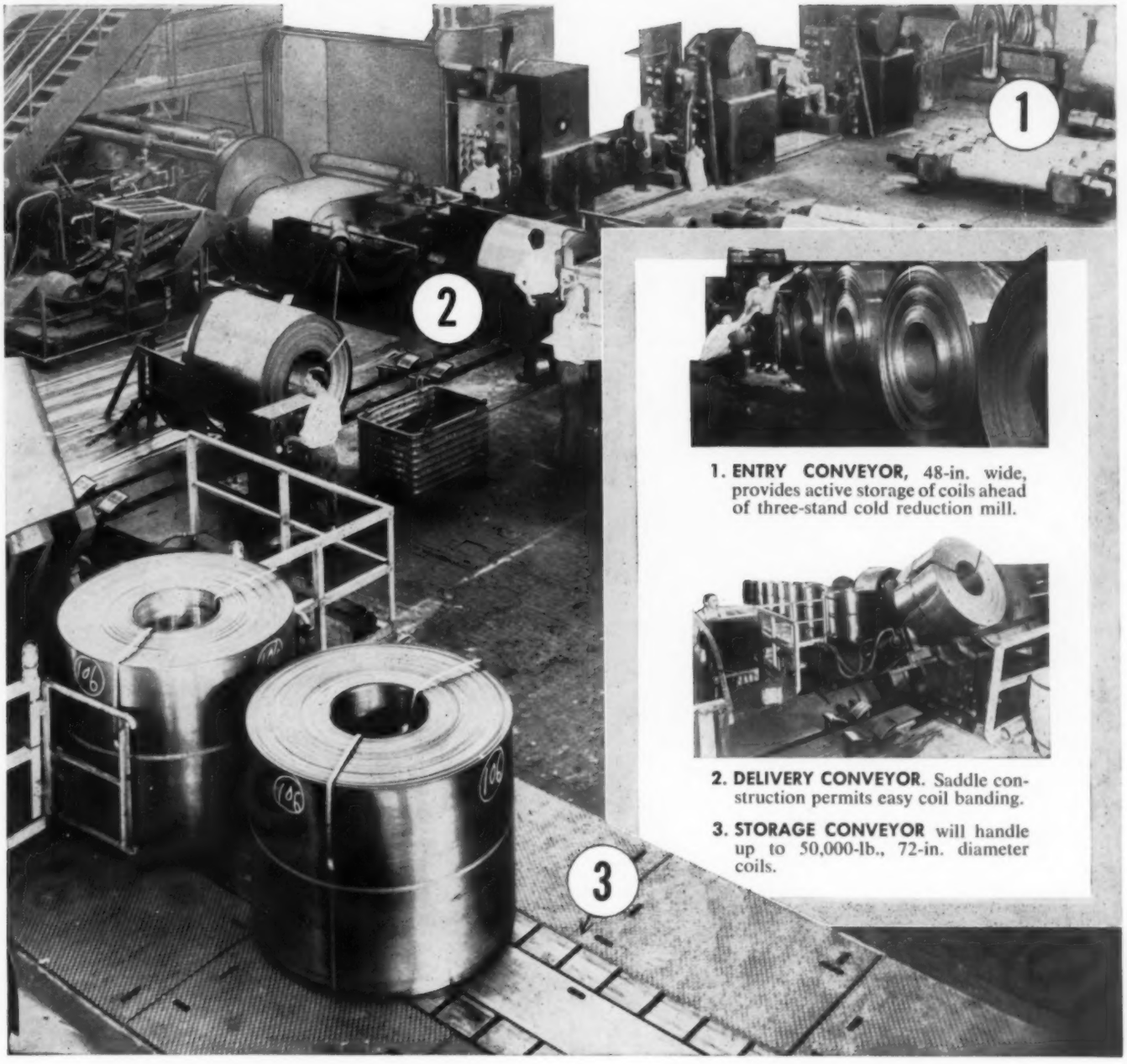
To the executives of more than 40,000 companies that have the Payroll Savings Plan . . . the 8,000,000 employed men and women who invest $160 million per month in Series E Bonds . . . the publishers of 500 business papers and the managements of radio, television and other media who give freely of their space . . . the Advertising Council . . . the advertising agencies who contribute their skills . . . to *all* of you who have had a part in the success of the Payroll Savings Plan, the United States Treasury offers its heartfelt thanks.

George Humphrey

Secretary of the Treasury

IRON AND STEEL ENGINEER

3 Link-Belt coil conveyors help boost Ford steel output



1. **ENTRY CONVEYOR,** 48-in. wide, provides active storage of coils ahead of three-stand cold reduction mill.

2. **DELIVERY CONVEYOR.** Saddle construction permits easy coil banding.

3. **STORAGE CONVEYOR** will handle up to 50,000-lb., 72-in. diameter coils.

Reduce idle mill time, handle much larger coils

As part of their steel division's modernization program, Ford Motor Co. greatly increased their cold rolled steel capacity — without appreciable additions in floor space. A push-button coil handling system featuring three Link-Belt conveyors made it possible to handle much larger coils than before. In addition, gentle handling minimized scrap losses. And with idle mill time eliminated, even greater output is achieved.

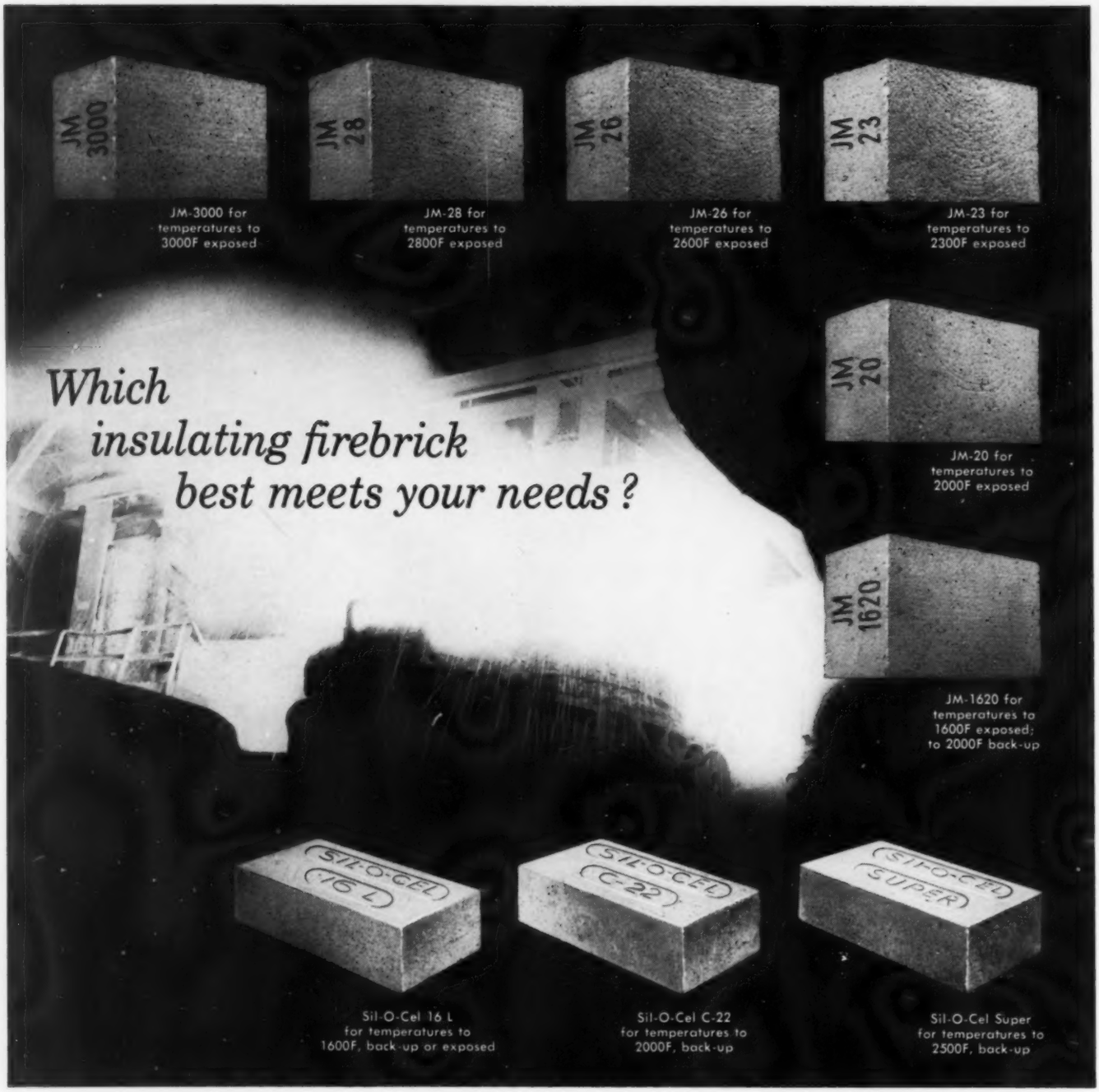
Link-Belt builds three types of coil conveyors to meet a range of requirements. In addition, auxiliary devices transfer coils from one conveyor to another . . . turn, lower, tilt or weigh them with ease and precision.

Link-Belt will gladly work with your own engineers, consultants and builders of mill and process equipment. For full information call your nearest Link-Belt office.

LINK-BELT

MATERIALS HANDLING, PROCESSING & POWER TRANSMISSION MACHINERY

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13.939


JM 3000
JM-3000 for temperatures to 3000F exposed
JM 28
JM-28 for temperatures to 2800F exposed
JM 26
JM-26 for temperatures to 2600F exposed
JM 23
JM-23 for temperatures to 2300F exposed
Which insulating firebrick best meets your needs?
JM 20
JM-20 for temperatures to 2000F exposed
JM 1620
JM-1620 for temperatures to 1600F exposed; to 2000F back-up
SIL-O-CEL 16 L
SIL-O-CEL C-22
SIL-O-CEL SUPER
Sil-O-Cel 16 L for temperatures to 1600F, back-up or exposed
Sil-O-Cel C-22 for temperatures to 2000F, back-up
Sil-O-Cel Super for temperatures to 2500F, back-up

Only Johns-Manville's insulating brick family offers the right combination of properties . . . *for furnace requirements to 3000F!*

J-M's nine *different* insulating firebrick* means you never have to settle for a brick that's nearly right! Instead, you choose the one brick that best meets your needs . . . for such important properties as temperature resistance, load-bearing strength, conductivity and density.

Johns-Manville has two strategically located plants for the production of insulating brick: Lompoc, California, and Zelienople, Pennsylvania. Brick are available from the stocks of authorized Johns-Manville distributors in key industrial areas.

For complete information, call your nearest J-M representative. Or write for brochure IN-115A to Johns-Manville, Box 60, New York 16, New York. In Canada, Port Credit, Ontario.

**Sil-O-Cel® Super and C-22 insulating brick are for back-up use only*

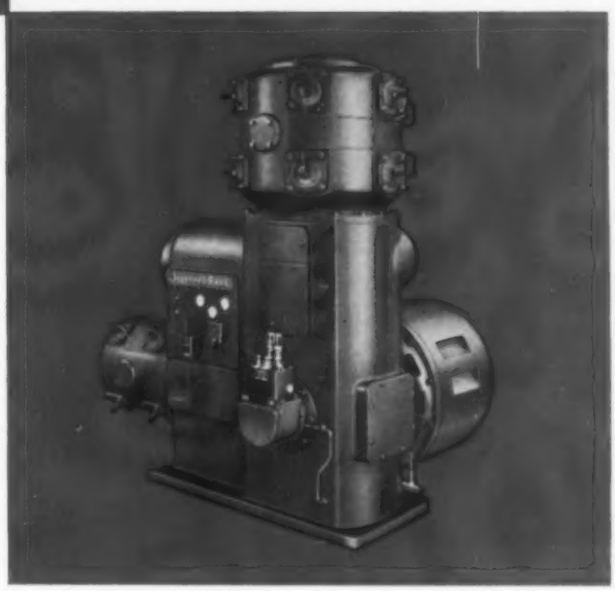
Johns-Manville REFRACTORY AND INSULATING REFRACTORY PRODUCTS

TWO READY-TO-RUN COMPRESSORS FOR

LOW-COST AIR POWER

IN YOUR SHOP

the PHE
- 75 and 100 hp packaged
- Opposed-piston balanced design



the XLE
- 125 to 250 hp packaged
- 300 and 350 hp with engine-type synchronous motor
- Thru-frame air flow

Why MODERN I-R DESIGN can reduce your air power costs and increase your production

Built tough for continuous full load, and refined for efficient performance at all loads.

Packaged, ready to run, each unit completely self-contained with crankshaft-mounted motor. Units up to 250 hp are shipped fully assembled, ready to hook up.

Full-floating aluminum bearings are foolproof, never need adjustment. They "roll with the punch" of every compressor stroke. Wear is distributed evenly around both inside and outside.

Closed crankcase never has to be opened for bearing adjustment, so dirt (the major cause of wear) is kept out of the oil.

Two-stage, intercooled compression, with I-R cylinders of proven design, makes most efficient use of horsepower.

Exceptionally smooth running balance permits small, simple foundation.

Compactness permits installation in small areas, requiring less of your valuable shop space.

CHANNEL VALVES give quiet, trouble-free operation and amazing long life due to air-cushioned action and reversible seat plates. Known all over the world for their efficiency, these valves are entirely different in design and principle from any other valve ever used. Channel valves are available only in I-R compressors.

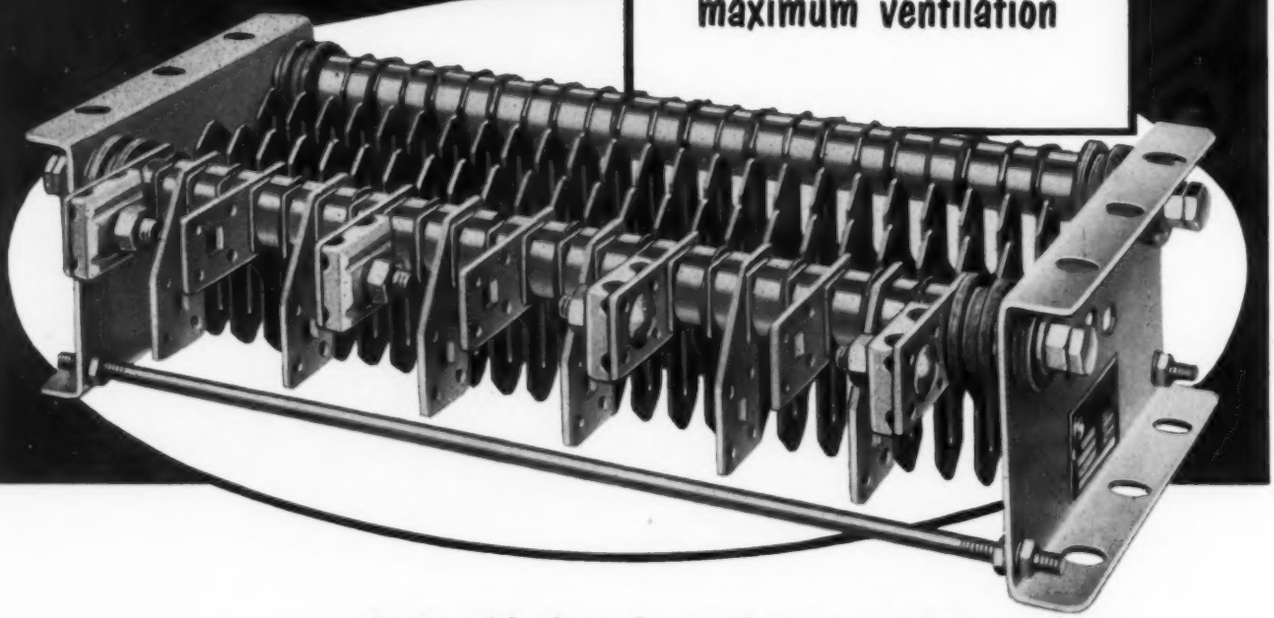
Ingersoll-Rand

1-381 11 Broadway New York 4, N. Y.

COMPRESSORS • CONDENSERS • AIR AND ELECTRIC TOOLS • TURBO-BLOWERS • PUMPS ROCK DRILLS • GAS AND DIESEL ENGINES

Resistor life depends on adequate ventilation.....

Patented P-G Grid Design assures maximum ventilation



P-G has BOTH!

STANDARD Resistors

WELDED Resistors

Write for Bulletins

Resistor life depends on adequate ventilation and how efficiently heat may be dissipated . . . P-G grid design equalizes the amount of air space surrounding each leg or loop to obtain even heat throughout the grid area. (Note illustration.) . . . Since heat is rapidly and evenly dissipated, hot spots fail to develop and longer resistor life is assured . . . For a nonbreakable resistor (only steel and mica used) specify P-G on your next application.

P-G

The Nonbreakable Steel Grid Resistor

THE POST-GLOVER ELECTRIC COMPANY

• ESTABLISHED 1892 •

221 WEST THIRD STREET, CINCINNATI 2, OHIO

If you're not in the book *you're a man without*

. . . . . a country
. . . . . a state
. . . . . a county
. . . . . a town
. . . . . a party
. . . . . a street
. . . . . a school
. . . . . a *vote*

Look at all the things you can lose, if you're not a registered voter.

If you're not in the book, you lock yourself out of the elections. The polls are closed to you. You can't vote on streets, or schools, councilman or mayor (not to mention congressman, senator or president). You don't even have the right to *complain* about your government and the way things are run!

But more than that, you cut yourself apart from your neighbor next door, your friends at the shop, your fellow members in union or club.

You lose the right to look that boy of yours in the eye when he wants to know if you're doing your part.

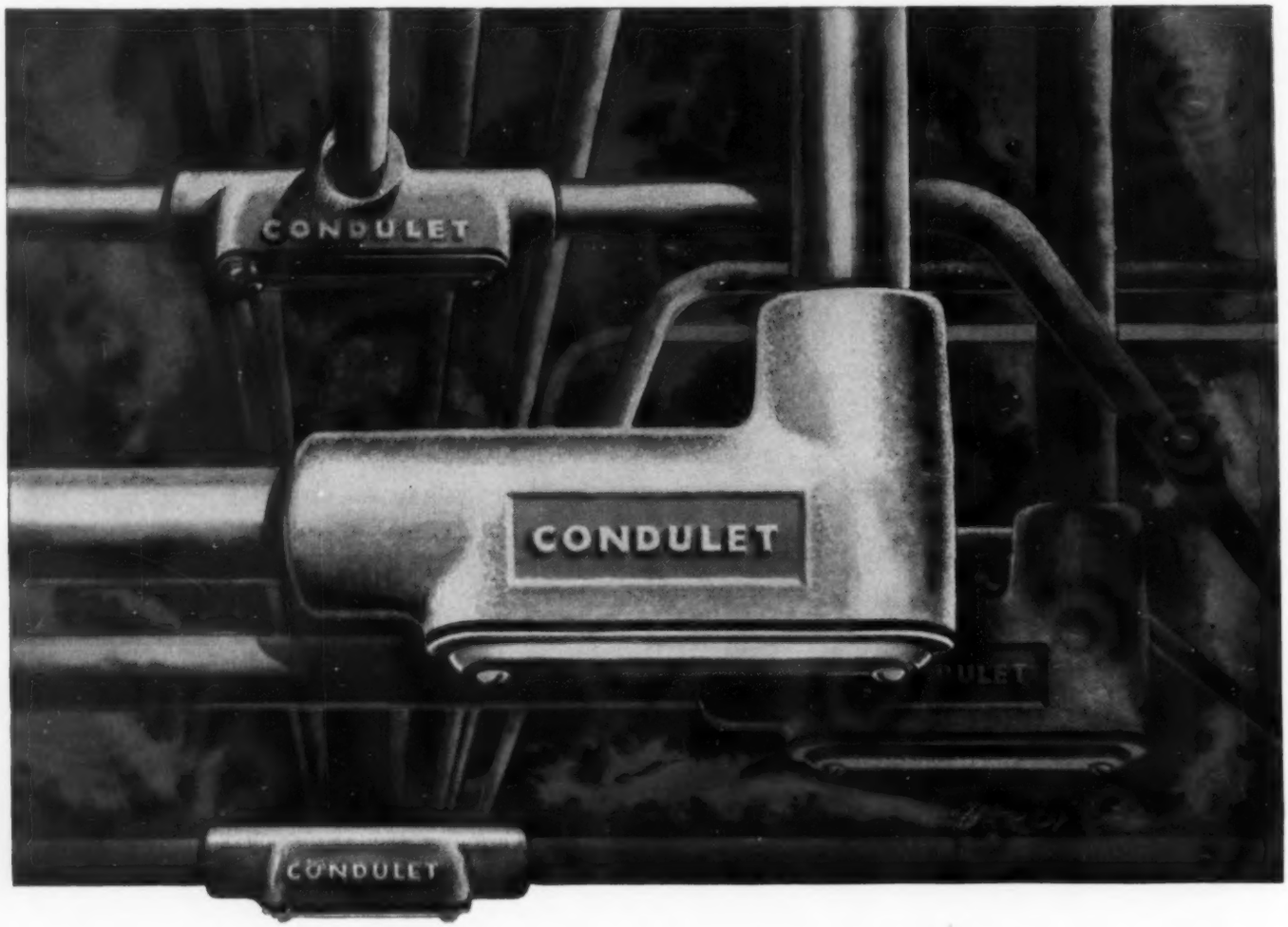
And you lose the self-respect that comes from knowing you can walk into the polls on Election Day—the one place in the world where all free men are really equal. Isn't it too much to risk for the little time that registering takes?

Get your name in the book
—and do it now!

Is your name in the book?

Nothing Beats

CONDULETS* and RIGID CONDUIT for FLEXIBILITY, SAFETY, ECONOMY



- **INSTALL ANYWHERE.** Crouse-Hinds Condulets and rigid conduit operate safely and efficiently under all atmospheric conditions and in all occupancies.
- **INCREASE CAPACITY EASILY.** You don't have to tear out and replace the entire system: merely pull additional wires or put in a larger size.
- **ASSURES MAXIMUM SAFETY.** Condulets are Taper-Threaded to provide a permanent low resistance path to ground.
- **GREATER DURABILITY.** Condulets and rigid conduit provide circuits with more protection against physical damage than any other wiring system. Further, Condulets are made of galvanized cast Feraloy, and resist corrosion.
- **LOWER OVER-ALL COST.** First cost is the entire cost — a minimum of maintenance is required.

COMPLETE FLEXIBILITY

There's a Condulet to meet every need of complex modern electrical layouts. See your Condulet Catalog.

A NATIONWIDE DISTRIBUTION exclusively through ELECTRICAL DISTRIBUTORS

*CONDULET is a coined word registered in the U.S. Patent Office. It designates a product made only by the Crouse-Hinds Company.

CROUSE-HINDS COMPANY

Main Office and Factory: Syracuse, N. Y.
Crouse-Hinds Company of Canada, Ltd.: Toronto, Ont.

OFFICES: Birmingham Boston Buffalo Chicago Cincinnati Cleveland Dallas Denver Detroit Houston Indianapolis Kansas City Los Angeles Milwaukee New Orleans New York Philadelphia Pittsburgh Portland, Ore. St. Louis St. Paul San Francisco Seattle Tulsa Washington RESIDENT REPRESENTATIVES: Albany Atlanta Baltimore Baton Rouge Charlotte Chattanooga Corpus Christi Jacksonville Reading, Pa. Richmond, Va. Shreveport

THE ENGINEERING MART

WHERE TO BUY
EQUIPMENT FOR SALE
POSITIONS VACANT
POSITIONS WANTED

AN *IRON and STEEL ENGINEER* SERVICE TO THE STEEL MILL OPERATORS

WHERE TO BUY

BIRMINGHAM DISTRICT

DIXIE ENGINEERING COMPANY
"Manufacturer's Agents"
812-813 Protective Life Building
BIRMINGHAM 3, ALABAMA
Sabel E. Baum — Telephone 4-0417

CHICAGO DISTRICT

PAUL W. WENDT & SONS
Manhattan Building
CHICAGO 5, ILLINOIS
District Representatives for
A. W. CADMAN MFG. CO.
HUNTER SAW & MACHINE CO.
GRAFO COLLOIDS CORP.

EHRET AND KINSEY
Board of Trade Bldg., 141 West Jackson Blvd.
Chicago 4, Illinois — Wabash 2-0449
Representing
THE CLEVELAND WORM AND GEAR CO.
"Cleveland" Worm Gearing and Worm Gear Speed Reducers — 29 Years
THE FARVAL CORPORATION
"Farval" Centralized Lube Systems—29 Years
LUBRICATION PRODUCTS COMPANY
"Strapax" Journal Box Lubricator — 23 Years
AMERIGEAR-ZURN, INC.
"Amerigear" Flexible Couplings — 8 Years
WALDES KOHINOOR, INCORPORATED
"Truarc" Retaining Rings — 10 Years
2400 W. Clybourn St. — Phone:
Milwaukee 3, Wisc. — Division 2-7844

PITTSBURGH DISTRICT

ROLLING MILLS and EQUIPMENT
FRANK B. FOSTER, INC.
2220 OLIVER BUILDING PITTSBURGH 22, PA
Cable Address "FOSTER" Pittsburgh

RITTER ENGINEERING CO.
Engineers • Distributors • Contractors
1515 W. LIBERTY AVE. — Phone:
PITTSBURGH 26, PA. — LOCUST 1-1303
TRABON—Centralized Lubricating Systems
METERFLO—Circulating Oil Systems
PARKER—Hydraulic & Fluid System Components
"Specialists in Lubrication and Hydraulics"

PITTSBURGH (Continued)

W. G. KERR CO., INC.
1005 Liberty Ave. — PITTSBURGH, PA.
Phone: ATlantic 1-4254
Representing:
FOOTE BROS.—Gears and Speed Reducers
REEVES—Variable Speed Drives
THOMAS—Flexible Couplings
WICHITA—Air Tube Disc Clutches & Brakes
TELSMITH—Telsmith Crushers
CULLEN-FRIESTEDT—Sheet Lifters—Welding Positioners—Track Cranes

METALLIC RECUPERATORS
(Air Preheaters)
For application to soaking pits, heating, and other types of metallurgical furnaces.
HAZEN ENGINEERING CO.
184 Sandy Creek Road — (Penn Township)
P. O. Box 10597 — PITTSBURGH 35, PA.
CHurchill 2-1750

ELECTRICAL INSTALLATIONS
PATTERSON EMERSON COMSTOCK, INC.
PITTSBURGH, PA.
STEEL MILLS—INDUSTRIALS UTILITIES
313 EAST CARSON ST. — ZONE 19

AUBURN AND ASSOCIATES, INC.
ENGINEERS
COMPLETE
ENGINEERING • DESIGN • LAYOUT
FOR
STEEL MILLS AND HEAVY INDUSTRY
923 Penn Ave., Pgh. 22, Pa.
Telephone COurt 1-5014

CONSULTING ENGINEERS

ROSS E. BEYNON
Consultant
ROLLING LAYOUT AND ROLL DESIGN
7658 Coles Avenue — Chicago 49, Illinois
Telephone SAginaw 1-3466

Consulting Engineers (Continued)

W. VANCE MIDDOUGH & ASSOCIATES
Consulting Electric Engineers
Engineering • Design • Layout
Heavy Industrial Power & Light
Frederick Building .. Cleveland 15, Ohio
Prospect 1-2060

Hickory 9-5141 — DETROIT, MICH.
WHITMORE LAKE, MICH. — WOodward 3-8706
LOYAL R. MILBURN
Hangsterfer's Laboratories, Inc.
Drawing and Cutting Compounds for Stainless Steel, Chrome Nickel and Titanium
Residence: — Office: 1928 Guardian Bldg
WHITMORE LAKE, MICH. — DETROIT 26, MICH

HOUSER AND CARAFAS ENGINEERING CO.
Engineering for Industry
4 Smithfield Street -:- Pittsburgh 22, Pa.
Phone: GRant 1-9929

MARTIN J. CONWAY
Consulting Fuel Engineer
111 South Duke Street — Millersville, Pa.
Tel. 6153
Steel Industry Representative for
CHEMICAL CONSTRUCTION CORPORATION
P-A- VENTURI SCRUBBER
Cleaning Blast Furnace, Converter, Open Hearth and Scarfing Gases. Bulletins Available.

EDWARD WINTERHALTER, P. E.
Basic Surveys, Plans and Design
Specifications • Performance Development
for
Electrically Powered and Controlled Facilities
Electric Power Supply & Distribution Systems
Chestnut Ridge Road — Coshocton, Ohio
Route 3 — 2483 W-2

NATIONAL DETAILING CO.
Designers and Detailers of Steel Fabrications
Consultants in Welded Fabrication of Machinery, Pipe and Plate Steel Products — Product Design and Re-Design of Castings for Welded Fabrications. . . Contract Basis.
4652 Echo Glen, Pittsburgh 36, Pa.
Telephone: TUxedo 1-1233

THE ENGINEERING MART
(CONTINUED)

PRODUCTS

MODERN
MILL OPERATORS' PULPITS
DESIGNED BY
WALLACE F. SCHOTT
CONSTRUCTED BY
JAMES CAMPBELL SMITH, INC.
WILLOUGHBY OHIO

POSITIONS VACANT

DOWELL

Chemical Engineers
Mechanical Engineers
Industrial Engineers
Chemists

Unlimited opportunities for advancement—applied science and engineering sales. Fast-growing service company offering chemical cleaning (boilers, lines, process equipment) to all phases of industry. Locations through most of U. S. Car furnished after training program; retirement, vacation, insurance benefits; interesting, challenging work.

DOWELL INCORPORATED
P. O. Box 536 Tulsa, Okla.
Subsidiary of
THE DOW CHEMICAL COMPANY

EXPERIENCED STEEL MAN WANTED
MAINTENANCE SUPERINTENDENT

Excellent opportunities with a steel plant specializing in electric furnace production and rolling of high quality killed carbon and alloy steels.

Apply by letter stating complete qualifications and salary expected. All communications will be held in strictest confidence. Address inquiries to Box 701, Iron and Steel Engineer, Empire Building, Pittsburgh 22, Pa.

THE COST OF AN AD THIS SIZE IS $8.00 PER INSERTION

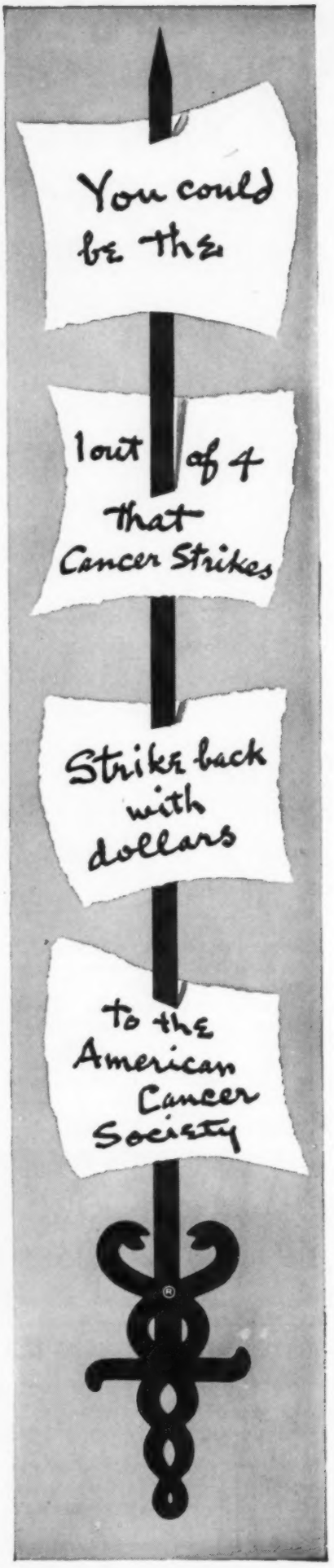
USE THE ENGINEERING MART

BOOK REVIEWS

(*Continued from page 237*)

"Psychology in Management" by Mason Haire has recently been published by the McGraw-Hill Book Co., Inc., Trade Book Department, 330 West 42nd Street, New York 36, N. Y. The book contains 212 pages, 6 x 9 in., is cloth bound, and sells for $4.75. Here is an interpretation from a managerial viewpoint of the nature of specific industrial problems and their psychological roots, among the aspects covered are motivation, learning, perception, attitudes, communication, leadership, training, productivity, and organization. Such important issues as role-perception in labor-management relations, psychological factors in wage-payment plans, and psychological forces restraining productivity are discussed. This is a presentation of illustrative and comprehensive material drawn from industrial practice.

"Metallurgical Thermochemistry" second edition by O. Kubaschewski and E. LL. Evans, has recently been published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. The book contains 410 pages, 5½ x 8½ in., is cloth bound, and sells for $10.00. This second edition reflects the growing interest and activities in the practical applications of chemical thermodynamics, and is presented as a complete revision. Much of the data has been brought up-to-date such as the thermochemical data of metal compounds, critical assessments of data for extraction metallurgy are now incorporated, and many new additional values are quoted. Alterations have been made on the estimation of thermochemical data chapter, some inaccuracies that slipped into the first edition have been omitted and two new sections on non-regular solutions and slag metal equilibria have been added, utilizing the findings of recent research on metallic solutions. The book is divided into the following sections, theoretical basis, experimental methods, the estimation of thermochemical data, thermochemical data, examples of thermochemical treatment of metallurgical problems, and each is treated under several subheadings or chapters. The book contains many tables, equations, and illustrations.



INDEX TO ADVERTISERS

JULY, 1956

A

Adalet Manufacturing Co., The 234
Aetna-Standard Engineering Co. 1
Air Products, Inc. 206
Alliance Machine Co. 222
Allis-Chalmers Manufacturing Co. 46, 47, 209
American Bridge Division, United States Steel Corp. 194
American Shear Knife Co. 231
Ampco Metal, Inc. 4
Atlas Car and Manufacturing Co. 237

B

Babcock and Wilcox Co., The 187
Bailey Co., William M. 44
Bailey Meter Co. 28
Bearings, Inc. 32
Berry Bearing Co. 226
Bethlehem Steel Co. 34
Birdsboro Steel Foundry and Machine Co. 204
Blaw-Knox Co., Foundry and Mill Machinery Division 6, 192, 193
Bliss Co., E. W. 210
Bloom Engineering Co., Inc. 228
Browning and Co., Inc., Victor R. 185
Buffalo Forge Co. 188

C

Chemical Construction Corp. 213
Cities Service Oil Co. 219
Clark Controller Co. 3
Clark Equipment Co., Industrial Truck Division 19
Cleveland Crane and Engineering Co. 48
Columbus McKinnon Chain Corp. 232
Corhart Refractories Co. 166
Crouse-Hinds Co. 250
Cutler-Hammer, Inc. ..... Cover 2

D

DeLaval Steam Turbine Co. 242
Delta-Star Electric Division, H. K. Porter Co., Inc. 184
Documentation and Licences, Paris, France ..... Cover 1
Dodge Manufacturing Corp. 213
Dowell, Inc. 172
Dravo Corp. 164, 211
Drever Co. 176
Duraloy Co., The 224

E

Eichleay Corp. 7
Electric Controller and Manufacturing Co., Division Square D Co. 35, 36, 37, 38, 169, 225
Electric Furnace Co., The 213
Electric Service Manufacturing Co. 216
Elliott Co. 8, 9

F

Farval Corp., The ..... Cover 3
Feller Engineering Co. 181
Flinn and Dreffein Engineering Co. ..... Cover 1

G

Gas Machinery Co., The 171
Gear Grinding Machine Co. 217
General Electric Co. 52, 178, 179

H

Hagan Corp. 198, 199
Hallden Machine Co., The ..... Cover 1
Harbison-Walker Refractories Co. 233
Harnischfeger Corp. 30
Heppenstall Co. 175
Homestead Valve Manufacturing Co. 27
Hunt and Son, Inc., C. B. 186
Hyatt Bearings Division, General Motors Corp. 39
Hyde Park Foundry and Machine Co. 232

I

Industrial Gauges Corp. 197
Ingersoll-Rand Co. 247
Iron and Steel Exposition 203
Ironsides Co., The 12, 13
I-T-E Circuit Breaker Co. 243

J

Johns-Manville Corp. 246

K

Kaiser Aluminum and Chemical Corp. 20
Koppers Co., Inc. 10, 239

L

Larco, Inc. 208
Lawrence Copper and Bronze Co 168
Lectromelt Furnace Co., Division McGraw Electric Co. 54
Leeds and Northrup Co. 195
Link-Belt Co. 50, 245
Loftus Engineering Corp. 220
Lubriplate Division, Fiske Brothers Refining Co. 231

M

Mackintosh-Hemphill Division, E. W. Bliss Co. 11
Mannesmann-Meer Engineering and Construction Co. 196
Manning, Maxwell and Moore, Inc. 236
Mansaver Industries, Inc. 234
Mesta Machine Co. 23
Miles and Partner, John, London, Ltd. ..... Cover 1
Morgan Construction Co. 43
Morgan Engineering Co. 241

N

National Carbon Co., Union Carbide and Carbon Corp. 29, 200
National Electric Coil Co. 212
National Roll and Foundry Co. 45
North American Manufacturing Co., The 235
Northern Engineering Works 190

O

Ohio Electric Manufacturing Co., The 42
Ohio Steel Foundry Co. 182
Osborn Manufacturing Co., The 51

P

Pangborn Corp. 214
Pennsylvania Transformer Co. 16
Pittsburgh Engineering and Machine Co. 230
Pollock Co., William B. 218
Poole Foundry and Machine Co. 254
Post-Glover Electric Co. 248

R

Ramtite Co., The 215
Refractory and Insulation Corp. 227
Reliance Electric and Engineering Co. 229
Rust Furnace Co. 163

S

Semet-Solvay Engineering Division, Allied Chemical and Dye Corp. 5
SKF Industries, Inc. 18
Spraying Systems Co. 15
Square D Co., EC&M Division 35, 36, 37, 38, 169, 225
Stamco, Inc. 208
Sun Oil Co. 2
Surface Combustion Corp. 40, 41

T

Texas Co., The ..... Cover 4
Timken Roller Bearing Co. 26
Torrington Co., The, Bantam Bearings Division 180
Treadwell Co., Inc., M. H. 170

U

Union Carbide and Carbon Corp., National Carbon Co. 29, 200
United Engineering and Foundry Co. 17
United States Graphite Co. 24

V

Vaughn Machinery Co., The 31

W

Wagner Electric Corp. 191
Waldron Corp., John 189
Wean Engineering Co., Inc., The ..... Cover 1
Wean Engineering Co. of Canada, Ltd., The ..... Cover 1
Wean Equipment Co. ..... Cover 1
Western Precipitation Corp. 221
Wheelabrator Corp. 33
Wilson Engineering Co., Inc., Lee 14

Y

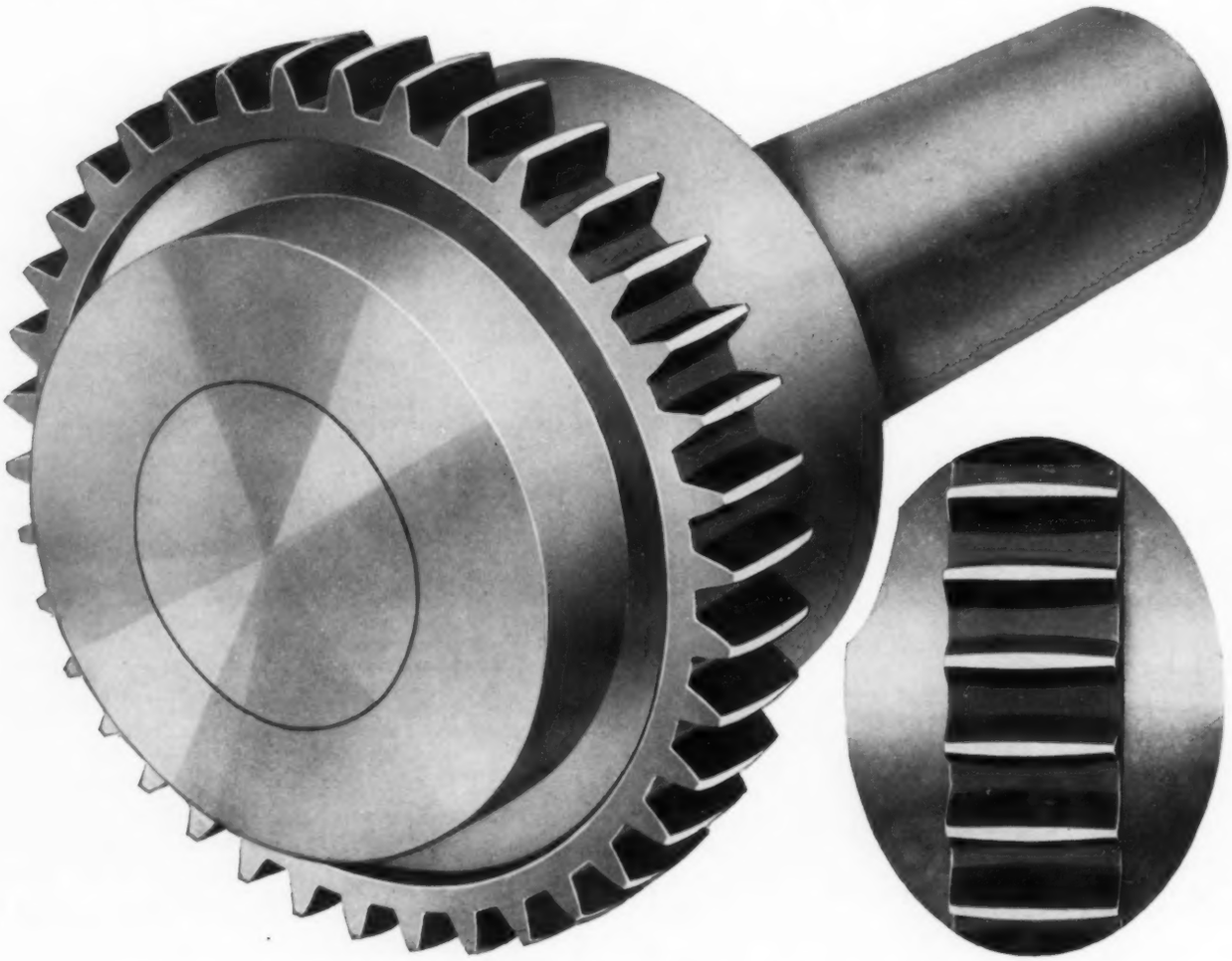
Youngstown Foundry and Machine Co., The 177

POOLE

CURVED TOOTH COUPLINGS FOR GREATER MISALIGNMENT

We are now equipped to furnish on special order, couplings up to and including size No. 12 with curve-sided hub teeth, permitting misalignment up to plus or minus 5°.

This feature solves many problems where excessive misalignment becomes unavoidable, such as coupling arrangements which necessitate changing centers of rolls etc., or any sort of drive requiring more than the standard plus or minus 1°.



The method by which this is done represents the very latest gear cutting process. Gear teeth cut by this amazing and ultra modern method are not only to a precise and absolutely true shape, but are also generated to tolerances of astounding accuracy.

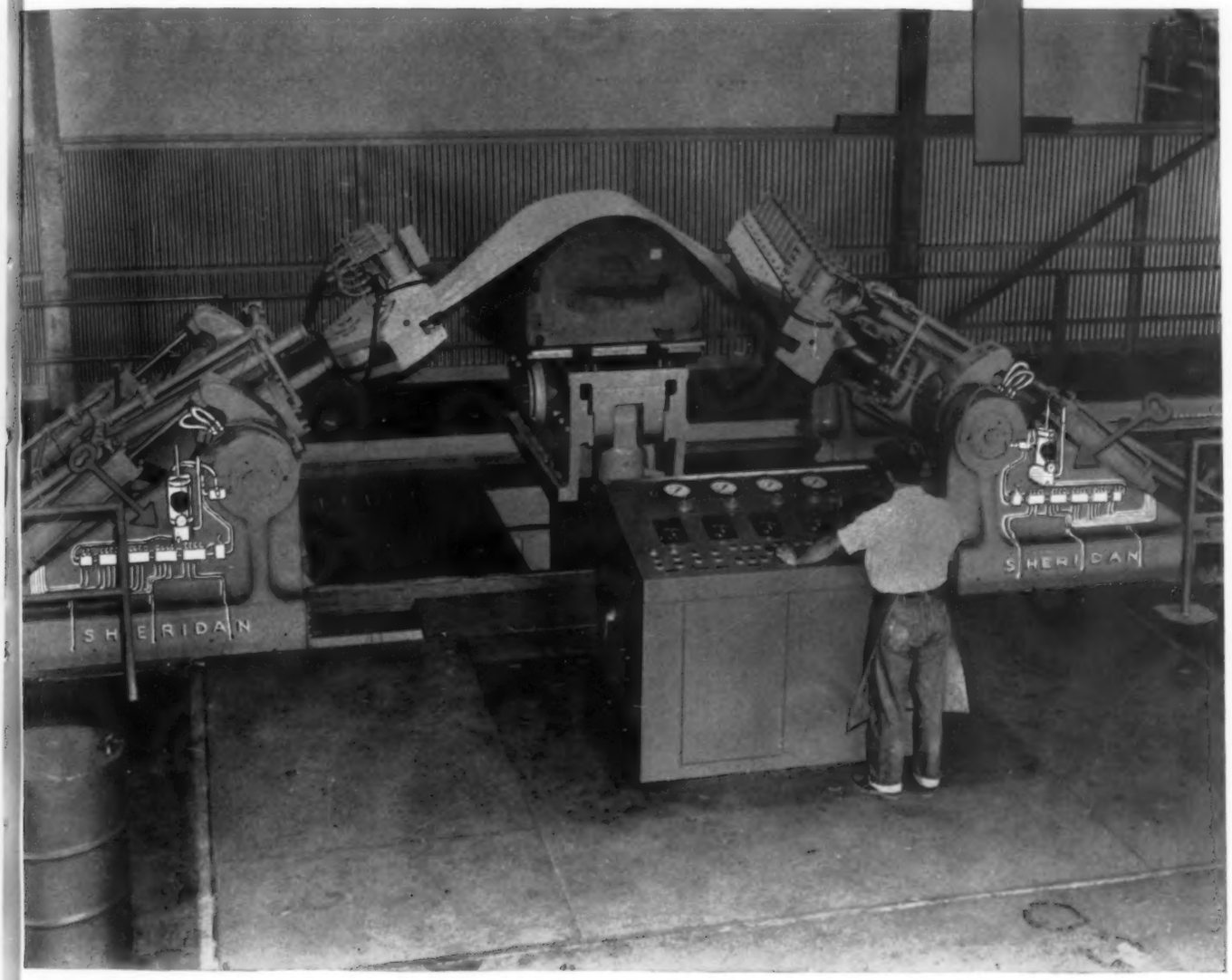
Engineers and draftsmen, when confronted with coupling problems involving more than the usual amount of misalignment, are invited to submit such problems to us for recommendation to suit their exact requirements.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY 1700 UNION AVE. BALTIMORE 11, MD.

Helping a metal stretcher to form 6′ x 30′ aluminum sheets into plane parts

FARVAL—
Studies in Centralized Lubrication
No. 186



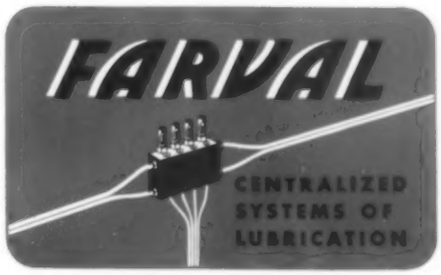
● Largest of its type on the West Coast, this 400-ton Sheridan wrap forming machine handles sheets of aluminum and other aircraft metals six feet wide and 30 feet long. It is equipped with a rapid setup panel on which the degree settings are centrally controlled, allowing the operator to work swiftly.

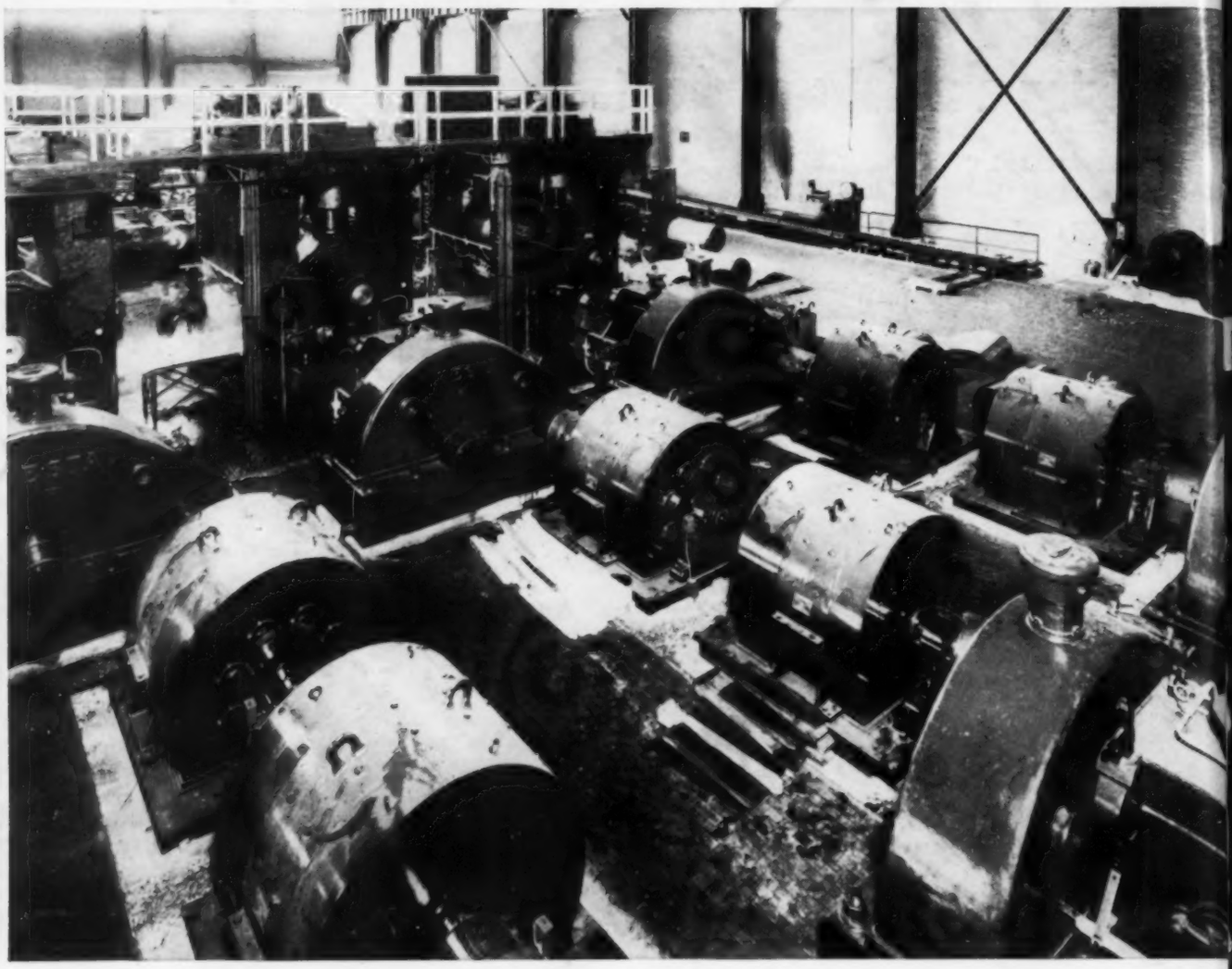
Farval is on the job to make sure that this swift operation continues without interruption. Through Farval's assured protection of bearings, downtime for oiling or for repairing bearings is eliminated. And, Farval contributes further to reduced costs through savings in oiling labor and lubricant.

Farval Centralized Lubrication Systems, manual or automatic, can be installed on new or old equipment. Why not let us send one of our lubrication engineers to inspect your plant equipment? He will present a written analysis of what Farval can do for you—without obligation, of course. The Farval Corp., 3278E. 80th St., Cleveland 4, O.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.

KEYS TO ADEQUATE LUBRICATION—
Wherever you see the sign of Farval—the familiar central pumping station, dual lubricant lines and valve manifolds—you know a machine is being properly lubricated.





How polar additives improve gear lubrication

TO be effective, a lubricant for enclosed reduction gears and bearings must cling to metal even under adverse conditions. That is why *Texaco Meropa Lubricant* is fortified with polar additives—to assure a tough lubricating film that *stays on* the metal under *all* conditions.

In addition, you'll find that *Texaco Meropa Lubricant* has outstanding extreme pressure properties—EP that withstands shocks and heavy duty steady loads far in excess of manufacturers' requirements, and outlasts other lubricants.

Texaco Meropa Lubricant resists thickening; will not foam, will not separate, will not corrode gear or bearing metal.

Texaco Lubrication Engineering Service will gladly help you get the most efficient operation from all your equipment. Just call the nearest of the more than 2,000 Texaco Distributing Plants in the 48 States, or write:

☆ ☆ ☆

The Texas Company, 135 East 42nd Street, New York 17, N. Y.

TEXACO

TEXACO Meropa Lubricants

FOR STEEL MILL GEAR DRIVES